# The Federal Role and Activities in Energy Research and Development 1946—1980

## An Historical Summary

February 1983

Hewlett

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Prepared Under Contract to
Oak Ridge National Laboratory
for the
Energy Research Advisory Board,
United States Department of Energy

Printed in the United States of America. Available from
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road, Springfield, Virginia 22161
NTIS price codes—Printed Copy: A09 Microfiche A01

Department of Energy
Washington, D.C. 20585

ENERGY RESEARCH ADVISORY BOARD

JAN 3 1983

Mr. Louis H. Roddis, Chairman
Energy Research Advisory Board
110 Broad Street
Charleston, South Carolina 29401

Dear Lou:

I am pleased to submit this report to the Energy Research Advisory Board entitled "The Federal Role and Activities in Energy Research and Development, 1946-1980, An Historical Summary" by History Associates Incorporated. The report was prepared to support the ongoing activities of the R&D Panel and the Federal Role Study Group of the Energy Research Advisory Board. I believe the study will provide a useful discussion of the evolving Government energy R&D policy and that it should be of interest to ERAB and to the general energy R&D community.

The report was prepared under subcontract to Oak Ridge National Laboratory who provide staff support to ERAB. I should like to acknowledge the cooperation of both History Associates and Oak Ridge National Laboratory in responding promptly to our guidelines for this study.

Sincerely,

Thomas J. Kuehn

Thomas J. Kuehn
Executive Director

Enclosure

ORNL/Sub/82-22268/1

# THE FEDERAL ROLE AND ACTIVITIES IN ENERGY RESEARCH AND DEVELOPMENT 1946-1980:

## AN HISTORICAL SUMMARY


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and
Bruce J. Dierenfield



Date Prepared: December 1982
Date Published: February 1983



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Under

Subcontract No. 19X22268

for

OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37830
operated by
UNION CARBIDE CORPORATION
for the
U.S. DEPARTMENT OF ENERGY
Under Contact No. W-7405-eng-26

# PREFACE

Late in the spring of 1982, the Oak Ridge National Laboratory requested History Associates Incorporated to prepare this study for the Department's Energy Research Advisory Board. The study is intended to serve as a resource for the Board in defining an appropriate role for the federal government in energy research and development.

The contract for this study specified that it was to concentrate on the federal role since World War II, with only a brief summary of earlier federal activities. Further discussions indicated that our analysis of the federal role should focus on the demarcation between federal and industry participation.

The authors have tried to follow these precepts. The result is a sharply defined study designed to meet the needs of the Advisory Board. As history, however, the study has certain obvious shortcomings. First, by focusing precisely on (a) the federal role and (b) energy research and development, we have not extensively explored the motivations of private industry, nor have we made more than tangential reference to the larger dimensions of energy policy, of which research and development is only a part. Furthermore, in following the evolution of a large number of technologies over a period of thirty-five years, we did not intend to present a continuous account of each but rather have confined our narrative to critical turning points in their development. Finally, under the time constraints placed on our research and writing, we were unable to examine the full range of historical sources pertinent to this study, but we have made exhaustive use of the sources at hand.

With these limitations in mind, we have called this study "an historical summary" rather than a history. We believe that the report identifies the major trends in the emergence of the federal role as well as the principal factors influencing this process.

The sources for this study consist largely of those materials immediately available in the Department of Energy headquarters and in some other federal agencies in Washington. The largest single source of records, and the most significant for this study, was the archival holdings of the History Division of the Department of Energy. These archives, consisting of more than 3,000 cubic feet of records, probably constitute the largest single collection of documents in existence on the federal role in energy history. For this study, we found essential the History Division's holdings of the Atomic Energy Commission, the Energy Research and Development Administration, the Department of Energy, and the Office of Oil and Gas. At the Department of the Interior library, we consulted annual reports and information circulars from the Bureau of Mines and the Office of Coal Research. The congressional Office of Technology Assessment provided copies of its analyses of federal energy programs.

We also consulted debates in the Congressional Record, transcripts of hearings before congressional committees, and pertinent articles in newspapers and magazines. Finally, the History Division of the Department of Energy made available a number of short histories of the Department and its predecessor agencies prepared by the historical staff. We are especially grateful to Roger M. Anders, Archivist of the Department, and Prentice Dean of the History Division for assisting us in finding pertinent records.

Richard G. Hewlett
Bruce J. Dierenfield
HISTORY ASSOCIATES INCORPORATED

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# EXECUTIVE SUMMARY

During World War II, the federal government replaced both industry and private foundations as the source of funds for both basic and applied research. By the end of the war, the federal government was supporting and directing a vast research and development enterprise that included scores of government laboratories and hundreds of contracts with universities and other private institutions.

In the immediate postwar years, the Atomic Energy Commission provided almost all federal funds expended for energy research and development. In addition to funding basic research in the nuclear sciences, especially high-energy physics, the Commission developed several reactor concepts that seemed promising approaches to nuclear power. When some of these projects, launched under the government monopoly mandated by the Atomic Energy Act of 1946, began to show commercial potential, new legislation was enacted to permit greater industry participation. Under the 1954 act, the Commission attempted to minimize the federal role in developing nuclear power and encouraged private industry to set the direction and pace of reactor development. Thus, the first central-station nuclear plant, completed at Shippingport, Pennsylvania, in 1957, was mostly a government project; but just two years later, the first privately financed plant began operation at Dresden, Illinois. Commercial use of nuclear power appeared a reality in 1963, when a public utility selected the nuclear option as competitive with fossil fuel for the Oyster Creek plant in New Jersey. The Commission then decided to focus its attention on the breeder reactor as a long-term solution to the nation's energy supply problem. This policy culminated in a highly centralized systems approach to development of the breeder reactor, which seemed to bring the Commission full circle in the transition from government monopoly, to a lesser federal role, and back again to strong federal control of nuclear development but now concentrated on the breeder reactor.

The federal role in developing energy technologies other than nuclear in the 1950s and 1960s was miniscule. The Bureau of Mines continued modest programs to assist both the coal and petroleum industries, but in the absence of industry demands for a strong federal presence, these programs did not grow rapidly. While continuing to provide field services and technical information for the oil industry, the Bureau only sporadically funded studies of oil shale technology, and in response to severe economic depression in the coal industry during the 1950s, Congress created the Office of Coal Research in 1960. The Office supplemented the activities of the Bureau of Mines, which then turned its attention more toward mine safety research. The new organization, however, failed to achieve congressional expectations, and growth in coal research programs continued slow through the 1960s. In the early 1970s, under a new congressional authorization, the

Atomic Energy Commission expanded the programs of its national laboratories into nonnuclear research, while the National Science Foundation began to fund solar energy research as a supplement to the efforts of the National Aeronautics and Space Administration to develop solar energy for satellite systems. Like the energy programs in the Department of the Interior, these efforts were small and narrowly focused on specific fuel technologies for specific purposes.

The OPEC oil embargo in 1973 brought to a head the question of the appropriate federal role in energy research and development. Although government support had been growing steadily since World War II, no administration established comprehensive or coordinated control over isolated programs funded by many agencies. The Energy Research and Development Administration, created in 1974, was designed to provide this kind of direction. In addition to the enabling legislation, Congress enacted four companion bills to provide for development of renewable energy resources. These acts represented an attempt by Congress to broaden the federal role to include new technologies.

In drafting a comprehensive plan for all energy technologies, the Energy Research and Development Administration defined an active and influential role for the federal government, not only in providing funds and research facilities but also in working cooperatively with industry. As new energy technologies were brought closer to commercialization, the burden of cost-sharing for research and development was expected to shift from government to industry. The federal role was to aid in developing long-term, high-risk technologies and in basic research, but the private sector was always to bear its full share of the costs, especially as commercial status was approached. In supporting all energy technologies simultaneously, the Energy Research and Development Administration succeeded in rapidly expanding federal expenditures--for example, more than eight times in solar energy and almost three times in fossil energy--during the agency's brief existence.

The Carter administration completed the consolidation of the federal role in the energy field by bringing together the research, development, policy, and some regulatory functions in a single federal agency, the Department of Energy. The enabling legislation reflected the administration's determination first to formulate a national energy policy and then to tailor research, development, and regulatory programs accordingly. Thus, research and development programs were no longer to be evaluated from the perspective of technical considerations within individual energy systems but rather in terms of their estimated impact upon national energy policy. Under this strategy, the Department of Energy in the late 1970s placed greatest emphasis on conservation programs and energy systems close to commercialization. This decision resulted in sharp decreases in federal funding for nuclear energy systems--especially the breeder reactor, slower increases for renewable energy technologies, and greater stress on research and development for fossil fuels.

The National Energy Plan announced by the Reagan administration in July 1981 appeared to reverse the major objectives of the Carter administration by substituting the commercial market for federal directives in determining the course and pace of energy research and development. As a means of reducing the federal role, the new administration proposed to limit federal support to long-term, high-risk, high-payoff technologies while leaving near-term options to private industry.

The federal role in energy research and development has changed substantially in the three decades since World War II. In nuclear technology, the federal presence shifted from government monopoly in the 1940s and early 1950s, to a lesser federal role in the mid-1950s, as the private sector commercialized nuclear power, to an increasing federal role in the 1960s, but now focused on the breeder reactor as a long-term option. Conventional fuel technologies such as coal and oil enjoyed only modest federal support in the immediate postwar years, with only slow increases before 1974. Renewable energy technologies have received substantial federal support only since 1973.

Some of the factors influencing these fluctuations were:

1. The traditional American view that federal support of research and development should be minimal.

2. Growing recognition since World War II that some federal role was essential, particularly for basic research and for the development of long-term, high-payoff, high-risk technologies.

3. Political and ideological objectives, if widely shared by the public, which can change drastically from one administration to the next.

4. Direct threats to the national security or welfare.

5. The prognosis for development of specific technologies.

6. A public perception that only the federal government can provide the resources necessary for developing a specific technology.

Indeed, at any moment in history, several of these factors (and perhaps others) may influence the Executive Branch and Congress in determining the appropriate balance between federal and industry support of energy research and development. Thus, the precise definition of the federal role will continue to change from time to time. It seems clear, however, that the federal government will continue to have an essential role in developing promising energy technologies that are far short of commercialization. As development of a specific technology moves from experimentation into engineering and demonstration, opportunities for industry participation become more attractive. At that point, a partnership between government and industry may be appropriate; but if the public perceives the technology to be essential to the national welfare, the federal government will need to provide continuing leadership, if not substantial financial support.

# CHAPTER 1

## GOVERNMENT AND SCIENCE - THE AMERICAN TRADITION

Since the birth of the Republic, scientists and political leaders have recognized the interdependence of science and government. Even in the last years of the eighteenth century, the federal government depended upon scientists for essential knowledge and information, and scientists sought government support for their research. There has always been, however, a fundamental tension between the two. Scientists seeking outside support have been reluctant to risk the loss of academic freedom, which they believed sometimes accompanied government funding. Political leaders, aware of the value of scientific research in varying degrees, have usually been unwilling to fund research not directly related to national needs. Congress reflected a public attitude that scientific research should be supported only when its results promised clear and practical benefits to the nation. Although the Constitution gave Congress the power to promote the progress of science and the useful arts, during the first half of the nineteenth century, Congress appropriated only a trickle of funds for scientific research.[1]

The career of Thomas Jefferson epitomized the classic dilemma faced by federal executives through much of the nation's history. Perhaps no other President has had a better understanding of science or has appreciated its potential value to the national welfare than did Jefferson. His strict interpretation of the Constitution, however, stopped him from proposing federal funding for scientific research. In underwriting the Lewis and Clark expedition in 1802, Jefferson found two ways of escaping his dilemma. First, without supporting scientific research directly, Jefferson obtained funds under the commerce clause for projects that involved observations and data-gathering in both the biological and physical sciences. Second, he used military funds and personnel to provide logistic support for the expedition.

Jefferson's indirect solutions became traditional devices for government funding of scientific research in the nineteenth century. The federal government could fund a limited amount of scientific research by establishing projects within government departments or the military services or, in some instances, by granting contracts to individual scientists, but only when the need and the practical benefits were obvious. As the impact of the industrial revolution became more evident, especially during the Civil War, the federal government was forced to take a more active role in both scientific research and technological development. Naval officers like John A. Dahlgren and Benjamin F. Isherwood used scientific methods to develop new ordnance equipment and steam propulsion in Navy bureaus established in 1862 specifically to administer the development of these technologies. Dahlgren spent much of his time furnishing specifications and standards to private companies and testing guns which they offered to sell to the government. Both Army and

Navy officers had to deal with the swarms of inventors who beseiged them with new ideas and proposals.

To provide scientific advice to the federal government, Joseph Henry of the Smithsonian Institution, Alexander Dallas Bache of the Coast Survey, and Charles Henry Dana of the Naval Observatory joined forces with other scientists to form the National Academy of Sciences in 1863. Established by Congress as an advisory body, the Academy could be reimbursed only for the actual expense of research undertaken at the request of a federal department. By 1864, the Academy had five committees working on studies for the government, but after the war, the initial vigor of the Academy declined.

## The Scientific and Industrial Bureaus

The Civil War years also witnessed the application of scientific research in American agriculture. President Lincoln signed the act establishing the Department of Agriculture in June 1862, just five days before the Homestead Act became law, opening the vast reaches of the West to the expansion of American farming. Originally organized around scientific disciplines, the divisions of the new department seemed to concentrate on the interests of science more than on those of farmers. As a result, the department developed no effective system for responding quickly to urgent problems, such as the spread of "Texas fever" in cattle. In the face of this failure to meet practical needs, the idea grew even in the scientific community that the department should leave long-term research to the universities and restrict its activities to the practical problems of farmers. The result was the gradual emergence of the scientific bureaus within the Department of Agriculture during the last two decades of the nineteenth century.

By the end of the century, the agricultural bureaus had established a new pattern for federal participation in scientific research. Staffed by scientists who were government employees, the bureaus were organized around problem areas rather than scientific disciplines. They depended upon the land-grant colleges for some basic research and for new personnel. The bureaus worked so closely with the agricultural experiment stations in the states and cultivated so many ties with public groups and members of Congress that they became almost independent of control by the Secretary of Agriculture. Initially concentrating on research, the agricultural bureaus gradually became more involved in service and regulatory activities.

As large-scale industry replaced agriculture as the dominant economic activity in the United States early in the twentieth century, the federal government created new agencies to meet the needs of industry. The demand for standards, particularly in the electrical industry, led to the creation of the National Bureau of Standards in 1901. The Bureau of Mines, set up initially in the Department of the Interior in 1910, did applied research on the fuel qualities of various types of coals, engineering studies of mine structures, and research related to mine safety. By 1914, the Bureau had established a petroleum division, which took the lead in developing improved drilling and recovery techniques as well as encouraging conservation practices. Like the agricultural bureaus, the Bureau of Mines soon had regional experiment stations that worked closely with engineering departments in the state universities. Also like its agricultural predecessors, the Bureau saw its function as providing a research service essential to the development of new technologies, in this case those related to fuels for energy systems. The extraction and processing of fuels were entirely the functions of industry, but the Bureau of Mines had an independent and widely accepted role in conducting applied research.

While the agricultural and industrial bureaus concentrated on applied research directly related to government programs, basic experimental research remained almost entirely within the domain of the major universities, which had developed graduate programs in the sciences on the German model during the last decades of the nineteenth century. Supported at first by the philanthropies of captains of industry and later by large foundations created with industrial capital, the universities became centers for basic research in the physical and biological sciences. This distinction became the yardstick for federal participation in research through the early decades of the twentieth century.

## Impact of World War I

World War I put in sharp perspective two requirements of modern warfare: the need for centralized coordination of large-scale industry in a common effort of total war and the application of scientific knowledge and methods to both military and industrial technology. Reverting to administrative devices used during the Civil War, the military services were slow to recognize the need for new approaches. Not until 1916 was the Council of National Defense established to mobilize American industry for the impending conflict. The mobilization of scientific talent from the universities came even later through the efforts of the National Academy of Sciences. Members of the academy created the National Research Council, which recruited scientists from many disciplines to work on teams in problem-oriented research. Following military practices of the past, the armed services funded and had complete control over the projects. Individual scientists usually worked under direct government contracts or accepted commissions as military officers. The World War I experience thus reinforced the American tradition that in times of national emergency, federal control of emergency-related research was mandatory and total.[2]

World War I also reinforced the idea that the federal government could provide valuable research support for American industry. In 1918, the Bureau of Mines established an experiment station at Bartlesville, Oklahoma, to serve the mid-continent oil and gas industry. The station was federally owned and operated, but its creation was vigorously promoted by the local chamber of commerce, which helped to raise local construction funds from oil companies in the region. The station received regular appropriations from the State of Oklahoma and small cash grants (under $10,000) from corporations and trade associations. A second experiment station was created in 1924 at Laramie, Wyoming, as a cooperative project with the state university. The experiment stations not only received some private funding but they regularly sought outside guidance from industry, more often than from Washington, in setting research priorities. Bartlesville managers consulted with industrial associations such as the American Petroleum Institute and professional groups such as the Society of Automotive Engineers.[3]

Of all the research and development sponsored by the federal government before World War II, only the modest efforts of the Bureau of Mines were directly related to energy technology. In an era of cheap and seemingly inexhaustible energy resources, new energy systems and more efficient fuels were hardly a national priority. Therefore, research supported by the Bureau of Mines was directed more toward eliminating scandalously wasteful and hazardous procedures for extracting coals and petroleum than meeting growing demands for fuel. For a few years in the 1920s, the Bureau operated a small plant at Rifle, Colorado, to extract oil from shale, but this project soon lapsed. When Congress expressed some interest in 1935 in producing synthetic liquid fuels from the nation's vast resources of coal and oil shale, the Bureau started a modest research effort in 1937. In all these activities, the federal role was minimal. The Bureau provided only those research and engineering services requested by private industry, particularly by small producers who could not afford such activities. The Bureau also depended upon active cooperation with, and joint funding by, industry and state governments. The federal government maintained a supportive, not a dominant, role in determining the course of energy technology.

## Impact of World War II

When war clouds loomed again in 1940, Vannevar Bush, who had participated as a young engineer in World War I research projects, set out to apply the lessons of the first war to plans for the second. As a first step, Bush obtained an executive order creating the National Defense Research Committee, which he designed to be a more flexible and powerful entity than the National Research Council had been. Unlike the old council, the new committee would be a government agency staffed with government employees. Unlike the World War I military boards, the committee would be independent from the military services with its own authority and budget. Unlike the National Bureau of Standards, it would not be restricted to work in government laboratories but would be free to negotiate contracts for research and development with universities and private corporations.

The independent status of the National Defense Research Committee had far-reaching implications. It permitted the committee to cooperate with the armed services without fear of military control. The scientists themselves were able to suggest promising avenues for research. The government could decide which avenues should be pursued, but the organization and conduct of the research remained in the hands of the scientists. Although Bush, as chairman of the committee, used existing government laboratories whenever possible, he relied on the universities, independent research institutions, and private industry for most of the research. This objective required a very different type of contract from the procurement or research agreements typically negotiated by the military services. Because it was impossible to predict what resources would be required or what direction the research would take, Bush adopted a new contract form with a simple performance clause which required the contractor to conduct research on a specific problem and to submit a final report by a given date. Bush also directed that the contracts be written with institutions, not with individuals as had been the military practice. This arrangement enabled the scientists to concentrate on the work at hand rather than on administrative matters and permitted flexibility in staffing and defining research strategies.

As new technologies blossomed during the war, Bush applied the operating principles of the National Defense Research Committee to the Office of Scientific Research and

Development, the Manhattan Project, and other war research activities under his jurisdiction. By the end of the war, these organizations constituted an enormous research capability encompassing many disciplines of science and engineering, and all financed by the federal government. The annual expenditures to support these agencies exceeded the total of the entire federal budget before the war.[4]

This enormous expansion of federal support for research and development during the war all but excluded energy technologies. Only in the face of wartime shortages of petroleum products, particularly aviation gasoline, did the federal government take action to encourage the development of new sources of petroleum. The Synthetic Liquid Fuels Act of 1944 was intended to provide federal support for research and development which would encourage industry to enter the field. The act provided $30 million for five years to support research in the Departments of the Interior and Agriculture and to build demonstration plants, which were to be large enough to supply industry with cost and engineering data but small enough to pose no threat of competition with the petroleum industry. The Bureau of Mines established an Office of Synthetic Liquid Fuels to administer the program and to provide liaison with the Department of Agriculture.[5]

By 1945 it was clear that a new interdependence existed between science and government. Scientific research was no longer an activity peripheral to the mission of the government but an integral part of the process. Scientific inquiry was stronger and more far-reaching than ever before, but its strength now depended upon government support. The scale and cost of scientific research, both in the physical and the biological sciences, were often far beyond the resources of the universities or the foundations. The old distinction between government and university responsibilities no longer existed.

The old distinction was breaking down conceptually as well as financially. The neat definition of basic and applied research that had been applied with reasonable effectiveness before the war was now disintegrating. As Congress tried to formulate new relationships between government and science in the first years after the war, the debate raged over the definition of basic and applied research.

Bush had deliberately precipitated this debate by his decision to abolish both the National Defense Research Committee and the Office of Scientific Research and Development after the war. Even before the war was over, he had conceived a master plan for replacing these wartime agencies with new ones resting significantly on the distinction between basic research and development. Bush intended to structure the postwar agencies so that the precedent for government sponsorship of basic research would not be lost. In a bold move to insulate government-sponsored basic research from the political process, he proposed to concentrate the government administration of basic research in a single agency, which he called the National Research Foundation.

Applied research in the nuclear sciences was to be the responsibility of an atomic energy commission, while other military research was to be coordinated by the new Joint Research and Development Board, of which Bush himself would serve as chairman.[6]

A key feature of Bush's proposals for both agencies was that they would be managed by a part-time board of directors serving without pay, who would have indefinite terms and be subject to removal by the President only for specific reasons. Members of the Truman administration immediately recognized the proposal for what it was: an attempt to place research and development beyond the reach of politicians. Consequently, Truman withdrew his support of the original atomic energy bill and, in 1946, vetoed the measure establishing the National Research Foundation. Without the National Research Foundation, the whole question of the magnitude and nature of government support for basic research hung in limbo for four years until the National Science Foundation was created in 1950.[7]

## NOTES

1. The first half of this chapter is largely a synopsis of pertinent sections of A. Hunter Dupree, Science in the Federal Government: A History of Policies and Activities to 1940 (Cambridge: Harvard University Press, 1957), especially pp. 1-6, 20-28, 151-61, 280-83, 296-99, 302-14.

2. Richard G. Hewlett, "Mobilizing Technology for War: Thomas A. Edison and Vannevar Bush" (unpublished ms., 1979); Vannevar Bush, Pieces of the Action (New York: Morrow, 1970), pp. 31-44, 71-75, 171-72.

3. U.S. Bureau of Mines, Department of the Interior, Fifty Years of Petroleum Research at the Bartlesville Petroleum Research Center, 1918-1968 (Bartlesville, Oklahoma: U.S. Bureau of Mines with the State of Oklahoma, 1968).

4. Don K. Price, Government and Science (New York: New York University Press, 1954); Daniel J. Kevles, The Physicists (New York: Vantage Books, 1979), pp. 294-301.

5. House Committee on Mines and Mining, "Authorizing Construction of Demonstration Plants to Produce Synthetic Liquid Fuels From Coal and Other Substances," House Report No. 821, 78 Cong., 1 sess., Nov. 1, 1943; Senate Committee on Public Lands and Surveys, "Synthetic Liquid Fuels," Senate Report No. 445, 78 Cong., 2 sess., Oct. 6, 1943; House Committee on Conference, "Synthetic Liquid Fuels," House Report No. 1302, 78 Cong., 2 sess., March 28, 1944; Senate Document No. 3, "Demonstration Plants to Produce Synthetic Liquid Fuel," 79 Cong., 1 sess., Jan. 6, 1945; P.L. 78-290, 78 Cong., 2 sess., April 4, 1944, 58 STAT. 190.

6. Vannevar Bush, Science, The Endless Frontier (Washington: Government Printing Office), pp. 107-11.

7. James L. Penick, Jr., et al., The Politics of American Science, 1939 to the Present (Chicago: Rand, McNally, 1965), pp. 72-89; Richard G. Hewlett and Oscar E. Anderson, Jr., The New World, 1939-1946, Vol. I of A History of the U.S. Atomic Energy Commission (University Park: Pennsylvania State University Press, 1962), pp. 408-11.

CHAPTER 2

# NUCLEAR ENERGY--THE PERIOD OF GOVERNMENT MONOPOLY, 1946-1954

Nuclear technology was first developed in the United States as an activity of the federal government. The Office of Scientific Research and Development (OSRD), under Vannevar Bush's direction, sponsored the basic research needed to determine the feasibility of building an atomic bomb, and the initial research was performed under government contracts with major universities. When, in 1942, Bush and his advisors decided that large-scale industrial development was warranted, President Franklin D. Roosevelt assigned this task to the Army Corps of Engineers, which followed the Army's practice of building large production plants as government facilities to be operated by private contractors. Thus, research for the Manhattan Project followed the OSRD pattern of university contracts while development followed the Army's government-owned, contracter-operated (GOCO) system. In both instances, government control was absolute. Both OSRD and the Army insisted that all work be directed exclusively to the bomb project, and research and development teams were isolated from each other to prevent the exchange of information. The Manhattan Project was one of the best-kept secrets of World War II.[1]

## Postwar Plans for Nuclear Technology

A year before the war ended in 1945, Bush and his associates began to make plans for the development of nuclear technology in the postwar world. Impressed by the potentially far-reaching but as yet unpredictable implications of the new technology, they assumed that all research and development would have to be restricted to government programs, at least until effective international control of the design and production of nuclear weapons could be established. As they saw it, the government should have custody of all raw materials and deposits, all plants and equipment, all technical information and patents, and all contracts and agreements related to the production of fissionable materials. The government would not only be authorized to conduct research and development but it should also be empowered to prohibit such activities not under its control.

Although Bush and his advisors had some second thoughts about the wisdom of such absolute control by the time the war ended and the Manhattan Project became public knowledge, the bill drafted by the Army in the summer of 1945 to establish the Atomic Energy Commission reflected most of their earlier ideas. When scientists who had worked in the Manhattan Project laboratories and plants voiced strong objection to the form of government control specified in the bill, the Army proposed to add a declaration that "the Commission shall adopt a policy of minimum interference with private research and development and employing private enterprise to the maximum extent consistent with...this Act." As for the Commission's authority to conduct basic research, the Army offered no change other than a similar proviso declaring it the Commission's policy "to utilize, encourage and aid colleges, universities, scientific laboratories, hospitals, and other private or nonprofit institutions equipped and staffed to conduct research and experimentation in this field."[2]

These high-sounding declarations did not stem the rising tide of criticism from many atomic scientists, who were determined to assure freedom from government interference in scientific research and, at the same time, effective international control of nuclear weapons. Within a few weeks, support of the Army bill collapsed, and a special Senate committee on atomic energy under Senator Brien McMahon began drafting a new bill which recognized the paramount objectives of the scientists. The McMahon bill reflected a rationale for joint government and private participation in developing nuclear technology. "The effect of the use of atomic energy for civilian purposes upon the social, economic, and political structures of today cannot now be determined. It is reasonable to anticipate, however, that tapping this new source of energy will cause profound changes in our present way of life."

The purpose of the bill, therefore, was to develop atomic energy not only for military security but also to improve the public welfare, raise the standard of living, and strengthen free competition in private enterprise. Section 3 of the original McMahon bill directed the Commission to encourage research and development by private or public institutions and "to make contracts, agreements, arrangements, grants-in-aid, and loans" for this purpose. Section 9 declared that "basic scientific information" was to be freely disseminated while "related technical information" was to be released "with the utmost liberality as freely as may be consistent with...foreign and domestic policies."[3]

In the course of committee hearings during the spring of 1946 and later in House debates, some of the more liberal provisions advocated by the scientists were modified. The authority to make grants-in-aid was deleted by the House, and Section 9, which had originally been titled "Dissemination of Information," was replaced by a new section, "Control of Information." Otherwise, the essential features defining the federal government's role in developing nuclear technology remained intact.

## The Atomic Energy Act of 1946

As adopted, the Atomic Energy Act of 1946 reflected both the views of Vannevar Bush and his advisors on heavy federal control and the more liberal aspirations of Senator McMahon and his staff.[4] The opening declaration of policy was very close to the original McMahon bill, and the first objective of the act remained: "A program of assisting and fostering private research and development to encourage maximum scientific progress." The second objective of the McMahon bill, "A program for the free dissemination of basic scientific information and for maximum liberality in dissemination of related technical information," had been replaced by a much more restrictive clause:

> A program for the control of scientific and technical information which will permit the dissemination of such information to encourage scientific progress, and for the sharing on a reciprocal basis of information concerning the practical industrial application of atomic energy as soon as effective and enforceable safeguards against its use for destructive purposes can be devised.

Section 1 of the Act also called for "federally conducted research and development to assure the Government of adequate scientific and technical accomplishment" and for "Government control of the production, ownership, and use of fissionable material to assure the broadest possible exploitation of the field."

Section 3 of the Act stressed the Commission's responsibility to support research and development "by private or public institutions or persons," and authorized the use of "contracts, agreements, and loans" for this purpose. The Act, however, also directed the Commission to conduct research in its own facilities.

Sections 4 and 5, requiring government ownership of all fissionable materials and all facilities for its production and use, eliminated the possibility for any large-scale development activities by private industry, although private institutions could own research reactors and operate them for basic studies in the physical and biological sciences. Individuals and private institutions could have fissionable material in their possession, but the title to all such material remained in the government, which controlled its possession, transfer, and use.

Section 10 on the control of information virtually prohibited access to classified information on nuclear science and technology by private parties except when they were working under a Commission contract. The section provided for a special category of classified information called "restricted data," which the Commission could make available to contractors only after a full background security investigation by the FBI. The international exchange of information related to the industrial uses of nuclear energy was prohibited until Congress determined that effective international safeguards on the use of atomic energy had been established.

Thus, the 1946 Act virtually foreclosed private activities in applied research and development in nuclear technology. Reflecting the distinction established in the late nineteenth century between basic and applied research, the Act permitted private research only in the basic sciences, but applied research and development was to be the exclusive province of the federal government and its closely regulated contractors.

Implementing the 1946 Act

The Atomic Energy Commission quickly decided in 1947 that it would not operate government laboratories with government personnel as did the National Bureau of Standards and other federal agencies, but would continue the Army practice of using GOCO laboratories. Thirteen contracts totaling about $60 million were approved for fiscal year 1947. Almost half of this amount went to the Clinton Laboratories at Oak Ridge. Argonne National Laboratory received $11 million; the Radiation Laboratory at Berkeley, the new Brookhaven National Laboratory, and the new Knolls Laboratory being built with Commission funds for General Electric each received about $6 million.[5]

A more difficult decision for the Commission was to determine the character and function of the government laboratories. Almost entirely restricted to applied research during the war, all of the laboratories had aspirations for turning to basic research that had been set aside during the war. The question was: Should the old division of labor between government and private research be abandoned or modified to allow basic research in government laboratories and, if so, by how much? An even more fundamental question was whether the Commission should support more than a token amount of basic research. There was some question in 1947 whether the Commission would provide financial assistance to the Office of Naval Research, which had kept basic research in high-energy physics alive in a number of university laboratories by funding the construction of cyclotrons and other particle accelerators. Strong arguments from the Commission's General Advisory Committee swayed the decision in favor of greater federal support for basic research, a substantial program of basic research in the laboratories, and joint funding of accelerator projects with the Office of Naval Research.[6]

## The National Laboratories

By early 1948, the roles and functions of the national laboratories were well established. Berkeley and Brookhaven became centers for basic research in both the physical and biological sciences with a strong emphasis on high-energy physics. In addition to a comprehensive program in the basic sciences, Argonne was designated to be the Commission's reactor development center. While all three of these laboratories and the weapon laboratory at Los Alamos were operated by university contractors, the Oak Ridge National Laboratory was to be operated by an industrial contractor, then called the Union Carbide and Carbon Company, as were the Knolls Laboratory, operated by General Electric, and the Bettis Laboratory, operated by Westinghouse. The three laboratories operated by industrial contractors had some responsibilities for basic research, but their efforts centered on applied studies, mostly in developing fission reactors for civilian power or military propulsion systems. All of the laboratories, except Berkeley and Los Alamos, served to some degree as regional centers, where universities in those regions could do research with high-energy accelerators and other equipment too expensive for many universities to purchase and operate. Brookhaven, operated by a consortium of universities in the Northeast, came closest to the model of a truly cooperative regional laboratory working in the basic nuclear sciences, while Oak Ridge and Argonne had institutional ties to universities in the Southeast and Midwest.

By the end of 1948, the Commission was also funding a substantial program of unclassified basic research in the nuclear aspects of both the physical and biological sciences. In 1950, Commission support in nuclear research and development was as follows:

| Type of Activity | Physical Sciences | | Biomedical Sciences | |
|---|---|---|---|---|
| | Dollars (Millions) | Scientists | Dollars (Millions) | Scientists |
| 8 major government-owned laboratories | 18 | 750 | 7 | 300 |
| 4 major university-owned laboratories | 5 | 600 | 3 | 350 |
| Many industrial, education, research, and government activities | 8 | 800 | 7 | 700 |

Commission funding, plus that provided by the Office of Naval Research and other organizations in the Department of Defense, constituted a substantial part of all federal funding of basic research, thus fulfilling the intended function of the National Science Foundation until that agency was finally created and became effective in the 1950s. Federal support rested upon the premise set forth by Vannevar Bush and others in the postwar period that basic research provided the working capital of knowledge required for the later development of practical applications of technology.[7]

## Applied Research

In the area of applied research, the Commission's priorities in the late 1940s were: (1) to develop new designs for nuclear weapons; (2) to improve and increase the production of nuclear weapons and fissionable materials; (3) to develop nuclear propulsion systems for submarines and military aircraft; and (4) to explore promising approaches to a practical nuclear power plant. Only the third and fourth priorities were significantly related to energy research and development, and only the last was fully relevant. As a fourth priority, nuclear power development in the period of government monopoly received little support in relation to the first three priorities but generous funding when compared to other energy technologies enjoying government support at that time. Under the 1946 Act, the Commission had no choice but to develop nuclear reactors as government projects within the national laboratories. Three industry study groups composed of selected executives and engineers were given limited access to classified technical reports on reactor development in the years before 1953, but because the members of the study groups were unable to pass classified information on to uncleared personnel in their companies, industry participation was not significant.[8]

## The Atomic Energy Act of 1954

The election of a Republican administration in 1952 spurred hopes both within the party and in some sectors of private industry that the new administration would be able to reduce federal spending and reverse the trend toward what was seen as an unwarranted interference by the government in the operations of the market economy. The administration's first impulse was to reduce even further the Commission's low-priority funding of power reactor research and to give private industry the impetus to develop nuclear power. The Republicans soon discovered, however, that industry, despite claims to the contrary, was unable technically and financially to take on this responsibility. Without major revisions in the Atomic Energy Act, industry would not enter the nuclear field in any substantial way. Therefore, President Eisenhower ordered the Commission to give top priority to drafting amendments to the Act, while the Republican Congress brought pressure on the Commission to accelerate the development of nuclear power. In the summer of 1953, Congress authorized the Commission to design and build a full-scale prototype of a nuclear power plant. To encourage industry participation, the Commission invited private utilities to submit proposals for a joint project with the government. From the nine proposals received, the Commission accepted the offer from the Duquesne Light Company of Pittsburgh to provide the site at Shippingport, Pennsylvania, to build the turbine generator plant and to operate and maintain the entire facility. The company also agreed to assume about one-tenth the cost of developing and building the reactor, which Westinghouse would design and the Commission would own. Although the arrangement seemed, on the surface, to offer industry an opportunity for an effective partnership with the government, the Shippingport decision brought little satisfaction to many industry leaders when they learned that design and construction would be directed by Admiral Hyman G. Rickover, whose naval reactor project presented an example of tight and comprehensive technical management which left little room for an active industrial role.

The Shippingport project became the first of five reactors which the Commission proposed for its five-year reactor program anounced early in 1954. In addition to Shippingport, the Commission planned to build four experimental reactors, each to test a different type of reactor design. Three of these plants were to be built at the Commission's national laboratories, one by Rickover, and the fifth by a Commission contractor.

The virtual exclusion of private industry from the five-year plan spoke eloquently to the need to amend the Act. By the spring of 1954, the Joint Committee on Atomic Energy had captured the initiative for drafting what was now to be an entirely new atomic energy statute rather than a series of amendments to the old one. In a series of extended congressional hearings, both Commission officials and industry leaders presented their views on the proposed legislation. When the proposed Dixon-Yates contract became public knowledge, the question of private-versus-public power displaced most other issues. Congressional Democrats charged that, by ordering the Commission to contract with a consortium of electric utilities to build a coal-fired power plant on the Mississippi to offset power that it might otherwise buy from the Tennessee Valley Authority, the administration was attempting to involve the Commission in a nefarious scheme to destroy the TVA. The Dixon-Yates controversy rekindled old animosities from the 1930s over the role of the federal government in power generation and infected all subsequent debate on the atomic energy bill.

Republicans in Congress and industry spokesmen argued that all the proposed revisions were necessary if industry was to have any role in developing nuclear technology. Consequently, Congress wrote in certain provisions crucial to the development of nuclear power. The bill permitted private ownership of facilities producing or using fissionable materials (but not of fissionable materials themselves); authorized the Commission to declassify restricted data for nonmilitary uses; established a system for licensing the operation of nuclear facilities and the distribution and use of fissionable and other radioactive materials; liberalized the patent provisions; and permitted international cooperation in the industrial uses of nuclear energy.

Democrats in Congress contended that the United States' world leadership in developing nuclear energy could be maintained only with a large and vigorous federal program of reactor development. The Democrats and representatives of public power interests also argued that the information and patent provisions of the bill would "give away" to private industry millions of dollars' worth of nuclear technology developed at public expense and would replace government monopoly with a private one involving only a few large corporations. Senate debate on these issues, plus charges and counter-charges in the bitter public-versus-private power fight, resulted in a 180-hour filibuster which set a new Senate record for a two-week period. After six months of hearings and debates, the Atomic Energy Act of 1954 was passed by the Congress and signed by the President on August 30.[9]

In the narrow sense of partisan politics, the outcome was a victory for the Republican Congress and the President. Eisenhower had inspired the legislation, and Congress had enacted every key provision on the President's agenda. But in a broader sense, the new law meant that the national effort to develop nuclear power would include not only the resources of the federal government but also the experience and initiative of industry. The remaining question was whether the Commission and industry could devise an effective partnership.

## NOTES


1. Richard G. Hewlett and Oscar E. Anderson, Jr., The New World, 1939-1946, Volume I of A History of the U.S. Atomic Energy Commission (University Park: Pennsylvania State University Press, 1962), pp. 14-29, 41-52, 71-83, 227-29, 238-39.

2. Ibid., 411-15, 423-55. The original Army bill, known as the May-Johnson bill, was introduced as HR 4280. Congressional Record, 73 Cong., 1 sess., p. 9325.

3. The New World, pp. 483-530. The McMahon bill, S. 1717, is reproduced in ibid., pp. 714-22. James R. Newman and Byron S. Miller, The Control of Atomic Energy (New York: Whittlesey House, 1948).

4. Special Senate Committee on Atomic Energy, Atomic Energy Act of 1946. Hearings on S. 1717, Jan. 22-Apr. 4, 1946. (Washington: Government Printing Office, 1946). The Atomic Energy Act of 1946, Aug. 1, 1946, P.L. 585, 79 Cong., 60 STAT. 755-75.

5. Richard G. Hewlett and Francis Duncan, Atomic Shield, 1947-1952, Vol. II of A History of the U.S. Atomic Energy Commission (University Park: Pennsylvania State University Press, 1969), pp. 28-32.

6. Ibid., pp. 68-84, 96-126, 185-221.

7. Vannevar Bush, Science, The Endless Frontier, (Washington: Government Printing Office, 1945).

8. Atomic Shield, pp. 197-98, 435-36.

9. Ibid., pp. 492-98, 509-18; Richard G. Hewlett and Francis Duncan, Nuclear Navy, 1946-1962, (Chicago: University of Chicago Press, 1974), pp. 225-57; Atomic Energy Act of 1954, Aug. 30, 1954, P.L. 83-703, 68 STAT. 919.

CHAPTER 3

# THE FEDERAL ROLE IN PROMOTING A PRIVATE NUCLEAR INDUSTRY 1954-1973

Following the adoption of the Atomic Energy Act of 1954, the Commission faced a difficult task in implementing the provisions of the law. Within a few weeks, task forces began drafting procedures for providing some access to classified information on reactor technology and a complex series of regulations governing licensing procedures. But even more pressing was the need for some positive step that would demonstrate that the Commission was doing something about developing nuclear power. Within the Eisenhower administration there was growing concern that the government, and especially the Commission, had not yet come up with one solid achievement that would give substance to the President's momentous "Atoms for Peace" proposal presented to the United Nations in December 1953. The Commission was also fully aware of the fact that, unless it quickly produced an impressive plan for reactor development, the Joint Committee on Atomic Energy would propose one of its own. This latter concern became more urgent in November 1954, when the Democrats regained control of both houses of Congress.[1]

## The Power Demonstration Reactor Program

One month later, after very little discussion, the Commission announced a power demonstration reactor program, under which private companies were invited to design, build, and operate their own nuclear power plants with only limited assistance and funding from the Commission. The Commission would waive all fuel-use charges for seven years, although industry would be required to pay for fissionable material actually consumed in the reactors. The companies could perform some work in Commission laboratories and could negotiate contracts with the Commission to cover some costs for development, fabrication, and experimental operation of the plants. All proposals were to be submitted by April 1, 1955, and would be evaluated in terms of their probable contribution to achieving economically competitive power, the cost to the Commission of fuels and materials, the risk assumed by industry, and the competence and responsibility of the proposer.[2]

The Commission could take some comfort in the fact that the four proposals received in response to the invitation would extend into the demonstration phase of development four of the five reactor types which the Commission was already pursuing in the five-year program. In its haste to launch the demonstration program, however, the Commission had not fully developed the criteria that would be used in evaluating the proposals received. None of the proposals strictly adhered to the kinds of assistance that the Commission had offered to provide in the invitation. Two of the proposals went so far beyond the rather narrow limits set forth in the invitation that they took on the nature of government projects in which industry would participate, rather than being industry efforts using limited government support. Even the Commission's own limits on its participation went well beyond the expectations of some Republican congressmen, who challenged its authority to provide funds ostensibly for research and development if, in fact, such funds were to be used to offset construction and operating costs.[3]

## Problems in Industrial Participation

The extended discussions within the Commission during the summer of 1955 revealed the kinds of dilemmas faced in moving a new technology from government control into the marketplace. The Commission still had no real confidence that private industry was prepared to make sound decisions about the direction of nuclear power technology. Thus, the evaluation of the power demonstration proposals became not just a matter of matching them with the criteria in the invitation but also of appraising the technical merits of the reactor systems proposed. As it turned out, the most attractive proposals technically were those least responsive to the terms of the invitation and *vice versa*. The Commission's dilemma was one of trying to maintain technical balance in the program at the same time it was attempting to move the technology into the private sector.[4]

The Commission was also faced with what could be called the Shippingport dilemma. To the extent that the Commission agreed to furnish assistance beyond the terms of the invitation, the closer the power demonstration projects would come to being government-business partnerships of the Shippingport type. This kind of transformation would defeat the very purposes of the power demonstration reactor program by eliminating the possibility of private ownership and control. The smaller the percentage of government support, the farther away from the Shippingport model the new projects would be; but as the projects became more independent of government support, the more difficult it would be for the Commission to turn the course of development in a direction that seemed best for vital national interests.

Beyond these considerations, the Commission keenly desired a successful demonstration program, and it believed that the public would judge success only by the number of power reactors actually resulting from the invitation. The Commission also feared that it would discourage industry proposals in the future if it rejected any of the first four. With some ambivalence, the Commission accepted two of the proposals for further negotiation and rejected the other two, but with assurances that the Commission would be willing to consider revised submissions. The product of four months of deliberation would hardly impress either the administration or the Congress as a bold and aggressive response to insistent demands for nuclear power.[5]

## Pressures for Federal Programs

Official and public reaction to the power demonstration program seemed to confirm the Commission's worst fears. The President directed the Commission to give top priority to putting a modified version of a submarine reactor in an "Atoms for Peace" ship. The National Security Council insisted that the Commission give first attention to a small power reactor to be sold abroad, on the mistaken assumption that a small reactor could be developed more quickly than a large one and thus would give earlier demonstration of the "Atoms for Peace" idea. Convinced that neither demand would advance the development of nuclear power in a technical sense, the Commission succeeded in postponing the peace ship for a year and transforming the National Security Council directive into a second invitation under the power demonstration program to develop a small power reactor.

The second invitation had the advantage of minimizing the government's role in reactor development and answering the charges of public power groups that the first invitation excluded them from consideration. In addition to the kinds of assistance offered in the first round, the second invitation, announced on September 21, 1955, requested proposals for small reactors in three specific output ranges and offered broader assistance by providing that the Commission would take title to any portions of the plant constructed with government funds. In this sense, the second round represented a return to the type of joint government-industry project adopted for Shippingport. Six of the seven proposals received in response to the second invitation were from small power companies or cooperatives. There was at least one proposal for each range of capabilities set forth in the invitation, and virtually every type of reactor under consideration by the Commission was represented. The response also complemented the first round in terms of geographic distribution.[6]

In the Commission's laboratories in early 1956, the five-year program was still the focus of attention as the five original experiments were supplemented by one new project at Oak Ridge and two at Los Alamos. Descriptions of the five-year program suggested that the Commission was exploring a remarkable variety of approaches to nuclear power, each intended to determine the engineering feasibility of a different reactor design. Each approach was pictured as drawing on existing scientific and technical data and, in turn, contributing new information for the next generation of experiments or demonstration plants. The five-year program had the appearance of being rational and comprehensive. Its shortcoming was that it lacked focus. It offered no simple, direct, and predictable route to economical nuclear power.

This deficiency was significant in the congressional response to the Commission's initiatives. In the spring of 1956, the Democratic majority on the Joint Committee began hearings on legislation that would create a massive federal program in reactor development. The Gore-Holifield bill would have directed the Commission to build large-scale nuclear power plants at existing Commission production sites to provide electricity for those installations, to construct smaller experimental reactors at Commission laboratories, and to assist other nations in developing their own power reactors, all at a first-year construction cost of $440 million.

Open hearings on the bill revealed some of the Democrats' motivations in supporting the bill: an attack on the "private power monopoly," distrust of the Commission's professed enthusiasm for nuclear power, and a lack of confidence in industry's repeated commitment to nuclear development. Closed hearings, however, revealed that the center of committee concern was Cold War competition with the Soviet Union, whose nuclear power program, according to intelligence estimates, was far ahead of the United States. Senator Albert Gore epitomized committee opinion when he stated that to lose the nuclear race with the Soviet Union would be "catastrophic." The United States, Gore declared, had "a clear moral responsibility" to develop "this marvellous new source of energy...to dispel the Soviet propaganda that we are a Nation of warmongers." The bill was denounced by the administration as a waste of resources in a foolish "kilowatt race" with the Soviet Union and the British. After a bitter debate in the House of Representatives, the Gore-Holifield bill failed by just twelve votes.[7]

## Minimizing the Federal Role

The defeat of the Gore-Holifield bill and President Eisenhower's resounding reelection in 1956 strengthened the resolve of Chairman Lewis L. Strauss and his Republican colleagues on the Commission to minimize the role of the federal government in developing nuclear power. Although Strauss denied the charge in public, his Democratic opponents were correct in claiming that he would prefer to see the development of nuclear power delayed if it could not be done by private industry without government support. Eisenhower hoped that private participation would be strong, but he thought winning the nuclear race was more important. During 1957, Strauss went through the motions of cooperating with the Joint Committee in drafting a bipartisan reactor program, but in the end he refused to accept large federal projects. Strauss held doggedly to this position even when it became clear in the fall of 1957 that industry had badly underestimated the difficulties in developing nuclear power. Despite warnings from his own staff that the nuclear power program would collapse unless the Commission provided positive direction and substantial financial support, Strauss refused to give any commitments even to industry. Without that commitment, industry leaders cancelled plans for new proposals, and Strauss lost his bid to shift the development of nuclear power from the federal government to private enterprise.[8]

Withdrawal of industry support did not mean a loss of interest in nuclear power but rather reflected the conclusion that a joint effort was impossible if the government refused to exercise leadership and provide substantial funding. Few utility companies were either willing or able to invest hundreds of millions of dollars in a new technology without assurances of government support. The implication of industry's reaction was that the enormous costs of, and responsibility for, developing a new technology like nuclear power could not be absorbed by industry alone but had to be borne by society as a whole.

Strauss' experience also illustrated a hazard a federal agency may face in turning over the development of an energy technology to private industry. In so doing, the agency forfeits all influence over the future course of development and cannot even take credit for whatever achievements may ensue. Such a posture is untenable if the Congress and the public assume that the agency does, in fact, have a responsibility for seeing that the technology is developed quickly and in ways that will best serve the public interest.

It could also be said that Strauss proceeded almost entirely on political or ideological grounds with less attention to the technical considerations involved. That is, he was determined to build a private nuclear power industry even if that state of the technology made that all but impossible. Even in areas of basic research where Strauss himself admitted that a strong federal role was essential, he was motivated more by politics than by an appreciation of science, in this case to demonstrate the superiority of the

American free enterprise system over state socialism. Thus, Strauss increased expenditures for high-energy physics and controlled thermonuclear research to levels which even some scientists considered higher than warranted by the state of the art. In these instances, because basic research rather than development was involved, Strauss could justify a heavy commitment by the federal government as one way to surpass the Soviet Union in the peaceful as well as the military uses of nuclear energy.[9]

## Support of Basic Research

During the 1950s, the Commission followed the patterns of support established in 1947 for basic research in the nuclear sciences. Strauss reported that during his tenure as chairman, the Commission's physical research program had expanded from $43 million supporting 259 contracts in 1954 to almost $60 million and 369 contracts in 1957. Of the $60 million for 1957, about 70 percent was allocated to support 1,200 scientific man-years at the national laboratories and major research centers. The remaining 30 percent went to 366 research contracts with 118 universities, private laboratory contractors, and other government agencies. The universities matched the Commission's support with $9 million of their own funds.

In high-energy physics, much of the funding was going to the continued operation of the bevatron at Berkeley and the cosmotron at Brookhaven, the first generation of large proton synchrotrons; to new smaller accelerators at several universities; and to the new Zero Gradient Synchrotron at Argonne National Laboratory. In controlled thermonuclear research, the Commission continued to support theoretical studies at Berkeley, Livermore, Los Alamos, and Princeton University, where the first major fusion test device, the Stellerator, was authorized in 1957.[10]

## The Ten-Year Reactor Program

John A. McCone, who succeeded Strauss as chairman in 1958, was just as conservative as his predecessor--but less dogmatic--in his views on the role of the federal government in industrial development. McCone welcomed a report prepared by a group of advisors to the Joint Committee on Atomic Energy recommending goals for an expanded nuclear power program and steps that might be taken to reach them. During 1958 and 1959, at the behest of the Commission, the national laboratories and nuclear industry contractors conducted a series of detailed studies and evaluations of the reactor concepts then believed to hold promise for economic nuclear power. The results were carefully analyzed by the Commission staff and, on two separate occasions, by advisory committees. On the basis of these studies and recommendations, the Commission published a series of reports, known as the ten-year nuclear power program, which established short-term economic targets as well as long-range goals in economics, resource conservation, and international leadership.[11]

In its final form, the ten-year plan did not represent a radical departure from the past but rather an extension and more precise definition of earlier proposals, giving preference to those which seemed most likely to result in large central-station power plants within ten years. The plan assigned the Commission a major role in building experimental reactors and in determining the prototypes needed. After the Commission completed conceptual designs and general specifications for the prototypes, utilities would be invited to submit proposals for design, construction, and operation of the plants. The prototypes were not to be considered entries in the "kilowatt race" but rather as yardsticks of reliable data on probable costs, efficiency, and performance. The ten-year plan gave preference to light-water and organic-moderated reactors, which then seemed most likely to produce competitive power in the short term, but the plan also assigned high priority to the breeder reactor as essential in the future.[12]

## Nuclear Power in the 1960s

Although some of the projects assigned a high priority in the ten-year plan, notably organic-moderated reactors, were terminated after further research, the strategy for selection and development of proposals set forth in the plan continued to be used through the 1960s. In 1962, Chairman Glenn T. Seaborg reaffirmed the Commission's confidence in the imminent practicality of nuclear power and endorsed the general features of the ten-year plan. The Commission reported to President Kennedy that nuclear power had already been shown to be technically feasible; what remained were a number of small but technically difficult improvements which would make nuclear power truly economical. The Commission believed that "economic nuclear power is so near at hand that only a modest additional incentive is required to initiate its appreciable early use by the utilities." Thus, "the proper role of Government is to take the lead in developing and demonstrating the technology in such ways that economic factors will promote industrial applications in the public interest and lead to a self-sustaining and growing nuclear power industry."[13]

Seaborg stressed that water-cooled reactors--both pressurized and boiling--producing saturated steam were the closest to being economically competitive; in fact, the Commission believed that private industry could be relied upon to make the last refinements necessary. The low-temperature steam produced by water-reactors, however, posed a serious limit on their economic potential. For this reason, the Commission proposed to push other concepts using other moderators and coolants to achieve higher steam temperatures, improved economics, and better fuel utilization. For the long term, the Commission agreed that the liquid metal fast breeder deserved a high priority.

In 1962, 53 power reactors of all types were under design or construction in the United States at a total cost of $1,310 million. Costs incurred on these reactors in fiscal year 1962 were $303 million. Forty-six of these were civilian power projects ($197 million) and, of these, 24 were either power prototypes or experiments ($170 million). The sources of funding were as follows:[14]

| | FY 1962 Costs (millions) |
|---|---|
| Federal Government | $203.6 |
| Atomic Energy Commission | 197.5 |
| Department of Defense | 4.2 |
| Other federal agencies | 1.9 |
| Industry and Others | 99.9 |
| Privately owned utilities | 89.4 |
| Publicly owned utilities | 3.3 |
| Manufacturers, universities, and states | 7.2 |
| TOTAL | 303.5 |

To carry out the 1962 plan, the Seaborg Commission used conventional procedures for cooperative development of new designs for improved power reactors. Early in 1965, the Commission solicited proposals from industry for the design, construction, and operation of prototypes of the new reactors. Of the four proposals submitted, the Commission selected two for further consideration.[15]

## The Role of Industry

By 1962, the Commission could with confidence leave to private industry the commercial development of pressurized- and boiling-water reactors. Of all the reactor types investigated by the Commission's laboratories and contractors, light-water reactors had appeared the most attractive, and private industry had taken the initiative to build reactors of this type either with some Commission assistance under the Power Demonstration Reactor Program or as essentially private projects. By the end of 1962, six large central-station nuclear plants were in operation, ranging from the Shippingport pressurized-water reactor, which was almost entirely a government project, to the Dresden boiling-water reactor and the Indian Point pressurized-water reactor, which were built with private funds. The Yankee plant at Rowe, Massachusetts, had been built under the Power Demonstration Program, as were two smaller public power plants at Hallam, Nebraska, and Big Point Rock, Michigan. Five other large central-station plants were under construction: three boiling-water reactors (at Sioux Falls, South Dakota; Humboldt Bay, California; and Genoa, Wisconsin); a fast-breeder plant at Laguna Beach, Michigan; and a gas-cooled reactor at Peach Bottom, Pennsylvania.

Private industry was also making substantial technical and financial contributions to the development of prototypes under the Power Demonstration Program. By the end of 1962, one of these, at Elk River, Minnesota, was already in operation, and three more were under construction at Piqua, Ohio; Parr, South Carolina; and Punta Higuera, Puerto Rico. For both the full-scale plants and the prototypes, private industry designed and built the reactor facilities for the electric utilities.[16]

The Commission's conclusion in 1962 that water-cooled reactors were close to commercial acceptance reflected the heavy concentration by both government and industry on this type of reactor over the previous decade. Early research and development had been the product of government projects: Shippingport for the pressurized-water reactor and the experimental plant at Argonne National Laboratory for the boiling-water reactor. Subsequent engineering development of commercial power plants, however, had been the work of private corporations, with only limited assistance from the government. Westinghouse had applied the knowledge and experience acquired in the early naval reactor program in the Commission's Bettis Laboratory and at Shippingport to enter the commercial reactor field. The Yankee Atomic plant, completed in 1960, was a commercial application of the Shippingport design. Westinghouse followed the Yankee project with two larger plants completed later in the 1960s: San Onofre and Connecticut Yankee. Although all three plants were technically a part of the Power Demonstration Reactor Program, most of the funding came from private sources. Within a decade, Westinghouse designed and built ten additional plants in the United States and several abroad, all independent of government support.

General Electric, during the same period, followed a similar course in developing the boiling-water reactor. Scientists and engineers at General Electric cut their teeth on reactor technology in designing a submarine reactor for

Rickover in the Knolls laboratory, provided by the government. The company's first commercial plant, Dresden, was completed in 1959 as an independent project. In fact, of the twelve commercial plants built by General Electric before 1974, only one, the Big Rock Point plant in Michigan, used federal funds. These two large equipment manufacturers dominated the commercial reactor market in the 1960s. Only three other companies built nuclear power plants during that decade, and none of these companies built more than two.

The federal role in this process of commercialization was difficult to measure. Surely the early government projects at Shippingport and Argonne had given General Electric and Westinghouse a technical base that was indispensable in embarking on a commercial enterprise. From that base, the companies had developed the technology largely with their own personnel and facilities. Thus, in a strictly engineering sense, the nuclear power industry could be said to be largely a product of private industry. The continuing federal presence, however, in the form of basic reactor research in the Commission's national laboratories and the Commission's encouragement of electric utilities to select the nuclear option smoothed the path toward commercialization.

## The New Federal Role in Breeder Development

The breeder reactor posed a far more difficult technical challenge than had the light-water reactor. The first premise of the light-water approach had been to employ relatively well-established technologies to build reactors that would have commercial application within a few years. By comparison, the breeder reactor required extensive development of new and untested technologies which might take decades to master. In short, the Commission saw the breeder reactor as a long-term, high-risk, high-payoff project that would require heavy federal participation for at least a decade. With these facts in mind, the Commission adopted a complex systems approach that reflected both the difficulty and importance which the Commission assigned to the project. The Commission decided to tie the breeder program close to its headquarters staff and to set up a series of development projects involving several Commission laboratories and many companies, all under the coordination of the Division of Reactor Development and Technology. Milton Shaw, one of the most talented and aggressive engineers to emerge from Rickover's naval reactors program, was selected as director of the division.[17]

Shaw spent two years building up his staff with experienced engineers and devising a strategy for attacking the host of technical problems involved. By 1966, he had decided to concentrate his efforts on the liquid metal fast breeder reactor (LMFBR) and had won top priority for it. Shaw augmented his large staff of engineers and scientists at headquarters with a program office reporting directly to him at Argonne National Laboratory to coordinate field activities. He then divided the project into eight technical areas and set Commission engineers and contractors to work to develop an LMFBR master plan and detailed objectives, criteria, and standards for each of the technical areas. One of the most critical technical areas was the development of fuels and cladding materials. Two types of fuel materials were selected for development over a period of several years with other types to be studied later. To test these assemblies, Shaw's group made plans to build the fast flux test facility (FFTF) at the Pacific Northwest Laboratory. The FFTF was a major reactor development project in its own right and involved six major contractors. Similar programs were organized for the other technical areas.

One of the announced objectives of the breeder program was to involve private industry to the maximum extent possible, and a large number of engineering and equipment manufacturing companies took part. The complex management systems, however, and especially Shaw's determination to retain tight controls over every aspect of the technical projects gave rise to the kinds of criticism that had been directed at Rickover since 1948. In fact, the LMFBR program could fairly be called a larger version of the Shippingport arrangement and suggested that the Commission's use of industry in reactor development had come full circle, from Shippingport, through the Strauss era of minimum federal influence, and then back to rigid federal control and heavy support.[18]

This enormous commitment to the breeder took place at the very time that public confidence in nuclear power reached its zenith. In 1964, a private utility company announced for the first time that a nuclear plant (Oyster Creek) had been selected for construction "on a competitive basis" with fossil fuel. In 1966, the year that work on the breeder really started, the utility industry announced plans to build 26 nuclear power plants, which would meet more than half of the new steam-electric generating capacity planned for that year. After 1966, the number of new starts leveled off and then began to decline before the end of the decade. The Commission first began publicly to acknowledge environmental concerns about nuclear power in 1969. The Calvert Cliffs decision in 1971 and the year-long hearings on emergency core cooling systems (ECCS) in 1972 spurred the Commission to place greater emphasis on reactor safety research.[19]

## Basic Research in the 1960s

The trend toward large programs encompassing the resources of several national laboratories and private contractors became apparent in the 1960s in basic research as well as reactor development. In 1962, when the Lawrence Radiation Laboratory proposed a design study for a new proton synchrotron a hundred times or so more powerful than the bevatron, the potential size and cost of the facility appeared to be so large that the decision had to be made in the context of a national policy for high-energy physics. A scientific panel, appointed by the Commission and the President's Science Advisory Committee, reviewed the Berkeley proposal and several others before recommending in 1963 that a 200-Bev proton accelerator be authorized. The Joint Committee on Atomic Energy endorsed the Commission's national policy statement in 1965, and later that year the Commission arranged with the National Academy of Sciences to appoint a special site evaluation committee for a national accelerator laboratory. The site committee reviewed 126 proposals from 46 states recommending more than 200 sites for the laboratory. In December 1966, the Commission announced the selection of a site near Batavia, Illinois, a few miles northwest of Argonne National Laboratory, for the new facility, which later was named the Enrico Fermi Laboratory. Although funded by the Commission, Fermilab continued to receive policy guidance from the national scientific advisory committee. The Commission's prime contractor for the project was the Universities Research Association, Inc., created for this purpose by a number of universities. A joint venture of four engineering and construction companies performed engineering design for the facility, and construction began in 1969. The accelerator was first operated in 1972 and soon became a leading international center for research in high-energy physics.[20]

## Conclusion

For a quarter century after World War II, the research and development activities sponsored by the Atomic Energy Commission constituted a large portion of all energy research and development supported by the federal government. Not until the 1960s did the National Aeronautics and Space Administration begin to challenge the Commission's prominence in administering research and development, but most of NASA's research was not in the energy area. Thus, the national system of government laboratories, university and private research institutions, engineering firms, equipment manufacturers, and electric utilities, both public and private, funded by the Commission became the principal physical and institutional inheritance of the new Energy Research and Development Administration established in 1974. Perhaps even more important than the facilities were the contract forms and other arrangements which the Commission had devised over the years to define the role of the federal government and the place of industry in nuclear research and development. New leaders in federal energy programs in the 1970s sometimes were ignorant of, or tended to overlook, the stock of knowledge and experience which the Commission had accumulated, but as the following chapters will show, many of the Commission's institutional structures re-emerged in new forms in the 1970s.

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# CHAPTER 4

## THE FEDERAL ROLE IN DEVELOPING OTHER ENERGY SYSTEMS, 1945-1973

The history of federal energy involvement in the period after World War II to the 1973 Arab oil crisis is an uneven one. During this time, the government usually responded to events rather than initiating them. World War II and the Korean conflict made Congress painfully aware of America's increasing energy needs and its vulnerability to energy cut-offs; yet, in the 1950s, the government was also optimistic that the country possessed the resources needed to be energy self-sufficient.

This optimistic view of energy supplies was only one of several factors discouraging government funding of research on conventional fuels in the 1950s. One set of reasons was economic. Because the coal industry was then experiencing a long-term depression, there was little need for increased production, and the industry itself saw little need for research. At the same time, the petroleum industry feared a possible oil glut and its likely effect on prices. Hence, big oil producers did not lobby for government energy research programs.

A second set of reasons stemmed from policy considerations. The Eisenhower administration embraced a limited view of the federal government, which had important repercussions for energy research projects. Eisenhower believed that sound economic development had to be based on the efforts of private industry; he was wary of government programs and subsidies that industry might use as a crutch. He also took seriously the need for a balanced federal budget, not just for reasons of fiscal prudence but also as essential to national welfare and security. The President's political philosophy had a chilling effect on federal funding for conventional energy research and development.

## Postwar Growth of Petroleum Research

In the immediate postwar decade, petroleum replaced coal as the primary energy source for industry and power. Concomitantly, the use of coal plunged dramatically by more than a third in only six years. A variety of reasons account for this historic shift in consumer fuel preference, including governmental policy, rising labor and transportation costs, and convenience.

Government policies were formulated from the perspective of individual energy technologies with little attention to their impact upon other sources or to national energy needs. Washington indirectly caused substantially higher coal transportation costs when it secured below-cost rates for hauling government freight and carrying military personnel; rail carriers necessarily began charging other customers more to make up for lost revenues. Higher transportation rates had a heavy impact on a bulky commodity like coal and increased fuel costs by 40 percent. Strikes and union demands resulted in reduced hours and higher wages in the coal industry to an extent without parallel in other fuel industries. Government agencies, like the State Department, did not move aggressively in combating a decline in the coal export market. The coal industry also suffered when the government continued to permit cheap foreign oil to enter the United States. On the other hand, the government acted benevolently toward competing fuels, especially natural gas, which enjoyed protected markets created by the Federal Power Commission. Last, homeowners quickly accepted the convenience of oil and gas fuel despite higher costs.[1]

## Coal Research by the Bureau of Mines

The Bureau of Mines was originally intended to assist mineral industries by collecting, evaluating, and disseminating scientific, technological, and economic data. In addition to such tasks as improving mining safety and developing explosives and helium reserves, the Bureau also conducted research on the common fuels--coal, petroleum, and natural gas--and on the potentialities of oil shale. But the major thrust of the Bureau's fuel research activities was in coal because of its relative abundance, the greater hazards of coal mines, and the neglect of safety measures by the industry's predominantly small companies.[2]

Despite the rather rapid decline of bituminous coal's position in the United States--from a majority energy supplier in 1943 to less than one-third in 1954--the Bureau of Mines did not, in the 1950s, move beyond its traditionally limited role. The depressed coal industry and the Eisenhower administration's policies helped to circumscribe the Bureau's research efforts. In petroleum, the Bureau felt compelled to avoid whole areas of research which were well funded by private industry. Refining processes in particular were the object of fiercely competitive industry battles. As a result, the Bureau devoted most of its meager resources to research on oil field equipment, reports on gas production, and on a survey of gasoline quality.

In the first coal research survey of its kind, the Bureau and Bituminous Coal Research, Inc., discovered, in 1955, that the federal government contributed little more to research than did coal producers, equipment manufacturers, and coal consumers. While the survey is flawed because the private sector was probably not adequately canvassed, it nonetheless painted a revealing portrait of coal research at the time.

Sources of Funds for Bituminous Coal Research

| | |
|---|---|
| Federal Government | $4,863,737 |
| State Governments | 579,727 |
| Commercial Coal | 2,452,284 |
| Captive Coal | 1,206,888 |
| Equipment Manufacturers | 3,220,810 |
| Other Industrial | 4,954,954 |
| University and Unidentified Funds | 104,000 |
| | $17,382,400[3] |

The Bureau's coal research program, which centered on coal chemistry and composition studies, technological investigations of coal extraction and use, and economic reports, relied on three major kinds of groups for this work. First, it deployed its own experimental stations and pilot plants in coal regions around the country, especially at Bruceton, Pennsylvania; Morgantown, West Virginia; and Tuscaloosa, Alabama. Some of these research facilities (the lignite station at Grand Forks, North Dakota, and the anthracite research laboratory at Schuylkill Haven, Pennsylvania) were constructed in the early 1950s. Second, the Bureau had cooperative research agreements with mining firms, such as the Consolidation Coal and Hudson Coal Companies. Finally, it worked with private research organizations such as Bituminous Coal Research, Inc., and the American Society for Testing Materials.[4]

## Federal Support of Oil and Gas Research

During World War II and its aftermath, the government gave more attention to oil and gas than to coal. President Roosevelt gave the Interior Secretary the task of regulating the petroleum industry in wartime. Immediately following the war's conclusion, President Truman asked the Secretary to unify and coordinate federal oil and gas policy and administration. In addition, Truman directed the Secretary to serve as a liaison between the federal government and the petroleum industry. Recalling the productive government-industry relationship provided by the Petroleum Council for War, the President suggested that the Interior Secretary create an industry organization to advise him on petroleum matters. Accordingly, in 1946, the Secretary set up the National Petroleum Council and the Oil and Gas Division (later the

Office of Oil and Gas) within Interior, which took responsibility for emergency preparedness, import policy, and availability and pricing questions.[5]

In the absence of strong demands from industry, the Bureau of Mines gave only limited support to research that would increase production. To mitigate the harmful effects of air pollution caused by high-sulfur petroleum and to study engine fuel performance, the Bureau worked with the American Petroleum Institute, the leading trade association. Throughout this period, but particularly in the 1960s, the Bureau also supported some enhanced fuel recovery projects. For example, in 1967, the Bureau joined the Atomic Energy Commission and the El Paso Natural Gas Company in Project Gasbuggy, which used a nuclear explosive to increase gas recovery from a low-permeable formation. These experiments showed that enhanced recovery was technically feasible but not yet economical in terms of current prices. In the case of Gasbuggy, environmental concerns, coupled with potential problems in public relations, caused the industry to lose interest.[6]

The limited nature of the federal government's role in petroleum research and development can be seen in a study prepared by the National Science Foundation for the period 1957 to 1967. Government funding increased from a low of 4.9 percent of all petroleum research and development in 1958 to a high of 17.6 percent in 1964, before declining in relative and absolute terms until the decade's end. At its peak in 1964, the government spent $72 million for petroleum research. After declining sharply to $13.5 million in 1969, federal funding for petroleum and natural gas again increased rapidly, almost doubling to $26.1 million in 1973.[7]

## Synthetic Liquid Fuels

For more than fifty years, the Bureau of Mines conducted and supported sporadic research on oil shale. Bureau activity tended to rise slowly over a period of years, only to be cut back sharply when the discovery of new oil fields reduced oil prices. This program represented the Bureau's obligation to discover new scientific and technological information to ensure sufficient fuel for future industrial and military needs. The modern period of oil shale research by the Bureau commenced with the enactment of the Synthetic Liquid Fuels Act of 1944. Under this legislation, which was spurred by wartime fuel shortages, the Bureau set up engineering development projects for oil shale mining, retorting, and refining near Rifle, Colorado, and laboratory research and development at Laramie, Wyoming.

The 1944 act also authorized research and development to extract petroleum products from coal and agricultural and forest resources. The latter studies were assigned to the Department of Agriculture, while the Bureau of Mines directed research on both oil shale and coal through its new Office of Synthetic Liquid Fuels, which established a small Washington staff and assigned more than a hundred scientists and technicians to several field experiment stations in 1945.

Germany's extraordinary success in producing petroleum products from coal during World War II made German technology a primary target for American technical teams entering the Third Reich with advancing Allied forces in 1945. More than 200,000 pages of German technical reports provided the starting point for the American postwar effort in coal-to-oil processes. In the autumn of 1945, the Office of Synthetic Fuels made plans to use the German data in basic research at the Bureau's experiment station in Pittsburgh and in pilot plants in a new facility at Bruceton, Pennsylvania. Both the pilot plants at Bruceton and demonstration facilities at Louisiana, Missouri, were designed to investigate and improve upon the two extraction processes used by the Germans: coal hydrogenation and gas synthesis. The Bureau's station at Morgantown, West Virginia, conducted studies to produce carbon monoxide and hydrogen from coal for use in synfuel production processes. All the laboratories and the Rifle demonstration plant were in operation before the end of 1947.[8]

In 1948, Congress added a second $30 million appropriation to carry the synfuels projects through 1952. With these funds, Bureau personnel at Louisiana, Missouri, were able to complete the coal hydrogenation and gas synthesis demonstration plants. The development work at Louisiana not only resulted in major improvements in the original German processes, but also made use of improved equipment designed and fabricated in the United States. By the end of 1952, the Office of Synthetic Liquid Fuels concluded that all three pilot plants had demonstrated technical feasibility to the point that it seemed reasonable to build a few private plants with government assistance. The Office then organized more than 130 cooperative projects under agreements with twenty-eight private companies to do further research and development on coal-to-oil processes, oil shale mining and processing, and product testing. Much of this effort was devoted to reducing costs in the processes already developed.

Although the growing federal program did produce valuable engineering data and experience, it did not create a synthetic fuels industry. In 1953, the Eisenhower administration decided to cut back the synfuels program to fundamental laboratory research and pilot plant studies. Despite the operating success of the demonstration plants, the Louisiana facility closed in June 1953. "Commercial development of our fuel resources," according to the Secretary of the Interior, "should be left to free enterprise."[9]

By 1955, the Hoover Commission on Organization of the Executive Branch of the Government recommended continuing the oil shale project at Rifle only until cost data were complete. Then the government, the Commission said, should decide whether to continue it. Announcing that the first phase in developing synthetic fuels was complete, the director of the Bureau of Mines did not request further extension of the act, and the program formally ended in May 1955. The director told Congress that synthetic fuel research would continue as part of the Bureau's regular program but would concentrate on improving existing methods and developing new processes.[10]

Once the federal program had been terminated, private industry began to take a larger role in cooperative projects with the Bureau of Mines. In 1961, the Bureau called on the Skyline Oil Company and the University of Utah to conduct an experiment on methods to determine the richness of oil shale deposits in eastern Utah. During the 1960s, the Bureau spent more on oil shale studies than on any other petroleum research.[11]

Private industry played an increasingly important role in oil shale research and development during the 1960s. Two major oil consortiums explored the commercial returns from shale. Mobil Oil, Pan American, Continental Oil, Phillips Petroleum, Humble Oil, and Sinclair Oil leased the Bureau facility at Rifle and substantially increased production. Later, another six-member oil group set up the Colony Development Operation at the Parachute Creek, Colorado, site. Only after the oil embargo of 1973-1974 did the federal government begin to fund more studies in domestic oil shale development, and then primarily in a leasing capacity.[12]

## The Coal Research Act of 1960

As coal consumption declined in the 1950s, congressional delegations from coal states attempted to increase federal funding by proposing federal coal research projects. In 1959, a number of senators from mining states, including

Thruston B. Morton of Kentucky and Everett M. Dirksen of Illinois, presented a bill to create an independent Coal Research and Development Commission, which would encourage, stimulate, and conserve coal through research. The Senators complained that the Bureau's research projects were not designed to provide short-term help to the declining coal industry and that such projects "deliberately avoided" research avenues then under study by private companies. To demonstrate that the Bureau of Mines had neglected coal research, Senator Robert C. Byrd of West Virginia noted that the Bureau in 1955 had allotted less than $5 million to coal research, while the rapidly expanding petroleum and chemical industries were spending hundreds of millions of dollars annually on research.[13]

All sides in congressional hearings agreed that federal support for coal research should be increased, but they were divided on how to accomplish this. The Interior Department, not surprisingly, opposed the idea of an independent coal agency, preferring to operate within "existing agencies." An Assistant Interior Secretary argued that an independent commission would not provide sufficient oversight of federal funds and that the coal research effort would be needlessly fragmented. President Eisenhower concurred with this assessment and pocket-vetoed the coal commission proposal in the fall of 1959, charging that the bill would have "blurred" governmental responsibility in research. The next year, Congress approved a substitute measure that met Eisenhower's concern that all coal research activity be centered in the Interior Department.[14]

The provisions of the Coal Research Act of 1960 directed the Interior Secretary to set up an office that would do four things:

1. Develop new, efficient means of extracting, preparing, and using coal.

2. Promote and coordinate coal research through contracts with coal trade associations, research associations, academic institutions, and state government agencies.

3. Establish expert technical advisory committees that would assist in evaluating research proposals and progress, as well as in avoiding project duplication.

4. Cooperate fully with all other interested agencies.[15]

The Office of Coal Research moved slowly in its early years. Throughout its first decade, the Office was understaffed and underfunded, and admittedly pursued only a small fraction of promising research avenues. By 1969, the Office had a staff of nineteen, including clerical employees, even though Congress had then authorized twenty-five staff members and had approved just over one-tenth of all research proposals. Funding for approved projects fell into two main categories. One category was the simple research grant to a recognized coal research group or academic institution. The second category was the cooperative agreement in coal gasification research. The Office used the latter, particularly after President Nixon's Clean Energy Message of June 1971. Within two months, the Office of Coal Research reached an agreement with the American Gas Association to fund jointly such contracts on a two-third/one-third ratio, with the Association providing the lesser amount up to $10 million over a four-year period. Under this arrangement, the Office authorized several joint research projects. Federal funding for coal research, now dominated by coal gasification efforts, nearly doubled in the year following Nixon's speech.[16]

According to a 1979 report by the House Committee on Science and Technology, the Office of Coal Research did not fully achieve congressional objectives. The chief purpose of the law was to effect "an economic revival of the coal industry" by creating a separate office that would devote itself specifically to short-term coal research. But the tight bureaucratic reins held by the Bureau of Mines led to few coal research grants. Moreover, the Office had jettisoned its original concept of funding exploratory technological development in new areas in favor of concentrating on a few significant inquiries. As a result, the Office had limited success in developing new processes which would speed recovery of the coal industry.[17]

## The Federal Coal Mine Health and Safety Act of 1969

With the coal research program largely transferred to the Office of Coal Research, the Bureau turned its attention more to coal safety and environmental questions. In large measure, this shift reflected increasing public concern over continuing mining accidents in the Appalachian fields and the pollutants released in coal burning. The government, under the Federal Coal Mine Health and Safety Act of 1969, "extended and accelerated" the Bureau's related research programs. The Bureau also retained technical services in industry, academia, and other government agencies through contracts, grants, cooperative agreements, and the transfer of government funds. By the early 1970s, 40 percent of the Bureau's coal research monies went to mining health and safety.[18]

## Nonnuclear Energy Research in the Atomic Energy Commission

At about the same time that Congress sought an escalated research program in coal, it also considered the possibility of using the Atomic Energy Commission's national laboratories for nonnuclear energy research. Although the Commission conceded, in the 1960s, that its "laboratories are not the exclusive resources of the atomic energy field," Congress did not authorize nonnuclear energy research by the Atomic Energy Commission until 1971. Even though some of its energy research had nonnuclear implications, particularly in areas of applied technology, physical research, and biomedical and environmental studies, most of the research monies from 1969 to 1972--the only period of significant funding before 1973--"should properly be classified as nuclear energy research." If fiscal year 1973 is included, the Commission's principal nonnuclear research categories were environmental, superconductivity, and solar energy. The Commission distributed its nonnuclear energy research funds chiefly to its own national laboratories, as well as to major universities. By 1973, the Commission boosted its nonnuclear energy research to $7.9 million, with much of the increase coming in energy storage and superconductivity.[19]

There were several reasons for the Atomic Energy Commission's slow start in nonnuclear energy research. Most obviously, the agency's organization act gave it a specific atomic energy mandate, which Congress did not broaden until 1971. Second, until the energy shortage became readily apparent to government officials in the early 1970s, the Commission had little reason to undertake nonnuclear exploration. Third, in some areas, notably solar energy, the Commission attempted to avoid unnecessary programmatic duplication, especially since the National Science Foundation held the major responsibility in that field.[20]

In fact, federally supported solar energy research received only "very modest" support in the quarter century after World War II. Lloyd O. Herwig, director of the solar energy program at the National Science Foundation, estimated that, between 1950 and 1970, federal solar energy research averaged only about $100,000 annually. Most solar energy utilization funds appropriated by Congress during this period went to the space program's efforts to power artificial satellites. Beginning in 1971, however, the government strengthened its commitment to solar energy research.[21]

Energy Research in the National Science Foundation

During the 1950s and 1960s, the National Science Foundation supported basic research in the physical sciences, mostly in the universities. Some of this work had potential applications in energy technologies, but the transfer of knowledge from scientific research to engineering development was largely serendipitous. In 1971, the Foundation established its Research Applied to National Needs (RANN) program to encourage this transfer and to direct it into useful areas. With RANN, the Foundation enlarged its research support to include national laboratories, private industry, and nonprofit research organizations. By encouraging research on specific objectives with "foreseeable benefits," the directors of RANN intended to "mobilize a portion of the nation's scientific talent and technological capability for resolving important problems of national concern." Through RANN, the Foundation was attempting to strengthen the federal role in research and development.[21]

Initially, energy research was only a small part of the RANN program and was confined mostly to paper surveys of energy resources and existing energy research projects already sponsored by the federal government and industry. In 1973, Oak Ridge National Laboratory began monthly publication of NSF-RANN Energy Abstracts, and the Foundation sponsored a large conference in energy demand, energy use, conservation, and institutional problems associated with energy use.[22]

From the beginning, RANN gave priority to solar energy. In 1971, the Foundation allocated more than $1 million to solar energy research projects and early in 1972 began coordinating its efforts with the National Aeronautics and Space Administration. By 1973, RANN had established the National Science Foundation as the lead agency for federal participation on solar energy research, which was now being supported by at least seven federal departments and agencies. In 1973, RANN supported research in solar heating and cooling of buildings, solar thermal conversion, photovoltaic conversion, wind energy conversion, ocean thermal conversion, photosynthetic production of organic materials, and conversion of organic materials to clean fuels.

RANN also included research in other energy technologies. In geothermal energy, RANN organized projects to study the geophysics of areas of high heat flow in several regions of the United States. In cooperation with the Bureau of Mines, universities, and the petroleum industry, RANN supported studies of coal gasification and liquefaction processes.

RANN's funding of energy research grew rapidly in the 1970s, rising from $5.1 million in 1971 to $36.4 million in 1975, when the National Science Foundation began to turn over to the new Energy Research and Development Administration its comprehensive research program of more than 100 operating projects in fossil energy, energy conservation, solar energy, and geothermal energy. Thus, during the early 1970s, RANN provided a focus for federally supported energy research until research and development on all energy technologies could be consolidated in a new federal agency.[23]

## Conclusion

The government's commitment to energy research and development betwen 1945 and 1973 was marked by some inconsistency, though generally speaking, it considerably increased federal funding. The immediate postwar years, troubled by uncertain foreign relations, convinced Congress and the President to give greater support for petroleum, natural gas, and oil shale. By the mid-1950s, Congress began complaining that the Bureau of Mines was neglecting coal research and attempted unsuccessfully to set up an independent agency for that purpose. Despite congressional efforts, coal research did not move as rapidly as hoped. In the 1960s, private energy companies picked up some of the slack in research and development, often with the government's blessing, in the form of facility and land leases. By the end of the period, President Nixon and Congress once more gave piecemeal government approval to energy research by funding such petroleum alternates as solar and geothermal power. Only in the National Science Foundation's RANN project was the federal government beginning to support a coordinated program in energy research and development.[24]

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CHAPTER 5

# RESPONSE TO THE WORLD ENERGY CRISIS, 1973-1974

By the early 1970s, three trends had emerged in the evolving role of the federal government in energy research and development. First, federal funding had greatly increased since World War II. Second, despite this fact, the federal government still had no comprehensive national energy plan. Third, as a consequence of the absence of a federal plan, some congressmen thought that federal expenditures were seriously out of balance. Since World War II, for example, the federal government had spent several billion dollars on nuclear research and development and not much more than $10 million on solar energy projects.

## Proposals for an Energy Agency

During the 1960s, in an era of relative energy abundance, the absence of a comprehensive federal energy program suggested a possible waste of federal funds on poorly conceived projects by federal agencies and some duplication of effort. As symptoms of impending energy shortages appeared more frequently in the 1970s, the consequences loomed more serious. In June 1971, President Nixon's energy message to Congress proposed the creation of a Department of Natural Resources, which would take over the energy resource activities of the Department of the Interior and the Atomic Energy Commission.

When Congress took no action on the reorganization plan as the energy situation worsened, Nixon announced in April 1973 that he would submit legislation to create a Department of Energy and Natural Resources based on his earlier proposal, "with heightened emphasis on energy programs." The administration's bill, introduced in Congress late in June 1973, bore the imprint of both the Atomic Energy Commission and the Joint Committee on Atomic Energy. In addition to creating the new department, the bill also provided for an Energy Research and Development Administration, which would transform the Atomic Energy Commission into a new, streamlined agency with "central responsibility for policy planning, coordination, support and management of research and development programs respecting all forms of energy sources."[1]

Congress showed considerable enthusiasm for the bill, in part because it promised to reduce the heavy concentration of federal research and development in nuclear technology. Senator Charles Percy, a cosponsor of the bill, suggested that the new agency could draw on research accomplishments of the Atomic Energy Commission and spur research on such specific energy sources as coal, gas, and solar energy. The new agency, Percy observed, could "use the well-proved system of national laboratories" to accomplish these goals. Senator Henry M. Jackson saw a role in basic research for the "less structured environments" of universities and private research firms, in addition to the national laboratories. Representative Chet Holifield believed that the new agency could start quickly to attack the nation's energy research and development problems, because it would have available an arsenal of scientific and technical talent and impressive facilities already built by the Commission. Holifield pointed out that the new Energy Research and Development Administration would be able to tap the "unique network" of national laboratories worth $9 billion, while the Office of Coal Research and the six laboratories from the Bureau of Mines would be able to provide personnel and equipment for fossil energy research.[2]

## Defining the Federal Role

One subject frequently discussed during congressional hearings on the proposed legislation was the appropriate roles of the federal government and private industry in energy research and development. Almost all witnesses agreed that some sort of cooperative effort was required. Witnesses representing the Atomic Energy Commission and its contractors advocated adoption of the practices which had evolved over two decades in nuclear programs. Others could suggest only that the demarcation between federal and industry roles be made on a "case-by-case basis," and no one ventured to suggest what specific criteria might be used in drawing such a line.[3]

One outstanding attempt to define the federal role was included in the report "The Nation's Energy Future," submitted to President Nixon in December 1973 by Dixy Lee Ray, chairman of the Atomic Energy Commission. At the President's request, Ray set up sixteen technical review panels consisting of 121 federal employees and 282 consultants from private industry to draft a comprehensive research and development plan covering all energy technologies. The plan proposed that the federal government spend $2 billion a year on energy research and development over the next five years; during that same period, the Ray report estimated that private industry would commit about $12.5 billion.[4]

The report set forth the following as responsibilities of the federal government:

> Establish the goals of national energy policy, including those for energy research and development.
>
> Identify, in conjunction with private industry, the research and development needed to reach these goals.
>
> Ensure, through appropriate exchange of information with industry, that essential research and development is done by private sources, joint private and Government undertakings, or Government efforts.
>
> Accelerate tecnological advances throughout the energy system.
>
> Discharge these responsibilities in a manner consistent with the Government's nonenergy responsibilities.

The report acknowledged that when national goals coincided with those of private industry, then the private sector should be given a major role. In some areas, however, "such as environmental concerns, basic research needs and national security, that may not be readily integrated into the profit motive," the federal government "should intervene to ensure adequate priority" to national needs. Guidelines for defining the government-industry roles were set forth as follows:

> Maximize industry participation, both to conserve Federal dollars and to speed the application of new processes.
>
> Tailor participation methods to individual industries.
>
> Ensure that no industry or firm realizes windfall profits at the taxpayers' expense, while preserving appropriate incentives that reward successful innovation.
>
> Use the best existing capabilities and expand Government facilities only when no capability exists nor can be created in the private sector.
>
> Press vigorously for the establishment of a single Government organization (Energy Research and Development Administration) to coordinate the national program and to plan, coordinate, and execute the predominant part of the Federal program.
>
> Develop Federal measures to reduce the commercial uncertainties of early application of new technologies.
>
> Ensure that efforts to attain energy goals do not unintentionally compromise efforts to attain other national goals (e.g., price stability, full employment, and consumer protection).
>
> Ensure that Federal actions taken in pursuit of other national goals also give full consideration to their impact on energy.
>
> Attain energy goals with minimal interference in the competitive market and in close coordination with Federal, state, and local regulatory agencies in regulated sectors.[5]

The report anticipated that application of these guidelines would mean that the bulk of private effort would be concentrated on short-term objectives. Thus, the federal government would have to fund a majority of medium-term energy projects and almost all of the long-term, high-payoff projects.

## The Arab Oil Embargo

When fighting erupted between Egypt and Israel in October 1973, the Middle Eastern oil producers decided to coerce the United States into settling the war to Arab satisfaction by withholding their exports. Since Middle East oil comprised 10 percent of American petroleum demand, the embargo had sharp repercussions. The sudden cutoff of oil imports from Arab producers injected a new, if short-lived, sense of national urgency over energy matters.[6]

President Nixon at first downplayed the possible effects of the emergency, calling the crisis "a challenge" and asking consumers to adopt such voluntary energy-saving steps as carpooling and turning down thermostats. He then turned to Congress for authority to open the Naval Petroleum Reserves, to relax environmental pollution standards, and to ration energy supplies. Even as Nixon called for preliminary energy-saving steps, the American people and their state governments met the emergency in their own ways. Residents in part of Rhode Island restored daylight savings time in order to reduce electric light demand in the evening. A Los Angeles radio station used its computers to form car pools for listeners. To cut fuel use by official state automobiles, the governors of Georgia, South Carolina, and New Jersey established a speed limit of 50 miles per hour.[7]

As the price of petroleum rose dramatically, people began driving less. Because of the economy's heavy reliance on the automobile and related industries, such conservation measures had a rippling effect: Car sales plummeted by 11.4 percent in October, some service stations went out of business, and hotels and restaurants attracted noticeably fewer customers. Those who continued to drive faced higher gasoline prices and the frustration of long lines at service stations. The New York stock market suffered its sharpest loss in eleven years. While some Americans remained skeptical about the cause of the oil shortage, many congressmen redoubled their efforts for federal energy legislation.[8]

Unfortunately, the Middle East War and the Arab oil embargo in the fall of 1973 turned national attention away from long-term planning of the type set forth in the Ray report toward emergency measures to meet what President Nixon called "the most acute shortages of energy" since World War II. The President agreed that Congress should temporarily set aside the portion of the bill creating the Department of Energy and Natural Resources, which had become highly controversial, and enact the second portion creating the Energy Research and Development Administration.[9] Even this smaller task proved formidable, and the Energy Reorganization Act of 1974 was not enacted until October.

As suggested in the Ray report, the new legislation placed the government's major research and development programs for all energy technologies under the Energy Research and Development Administration. From the Atomic Energy Commission, the new Administration acquired its programs on nuclear reactors, fusion research, uranium enrichment, and basic scientific research, in addition to its offices, national laboratories, and nuclear weapons research and production facilities. The Interior Department relinquished the Office of Coal Research and such nonregulatory functions of the Bureau of Mines as the energy centers, coal liquefaction and gasification programs, the synthane plant, and aspects of underground electric power transmission. ERDA also acquired the solar heating and cooling and geothermal power development programs of the National Science Foundation, as well as the Environmental Protection Agency's programs on advanced automotive propulsion. All told, ERDA gained 7,222 employees, and received a 1975 budget of $3.6 billion. The regulatory functions of the Atomic Energy Commission were transferred to the new Nuclear Regulatory Commission, which also assumed responsibility for reactor safety research.[10]

The new law reflected the difficulty encountered during congressional hearings in defining the federal role in energy research and development. Failing to come up with a satisfactory definition, Congress gave ERDA's administrator substantial freedom to fulfill the mandate of "continued conduct of research and development." For instance, in Section 107, the law authorized the administrator to employ a wide variety of arrangements, including contracts, agreements, and loans, with private groups or public institutions, or both, in order to implement research and development projects. The act specifically allowed the administrator "to take such steps as he may deem necessary or appropriate to perform functions now or hereafter vested in him."[11]

## Interest in Renewable Energy Resources

The months of debate on the energy reorganization bill in 1974 suggest that it might never have been adopted had it not been accompanied by four companion bills that assured a much larger role for the federal government in developing renewable energy resources. Witnesses at the hearings cited a number of arguments, principally economic, for increased federal participation. Klause Heiss, president of a New Jersey-based energy consulting firm, testified that renewable energy development could not easily be left to free market forces. He argued that the actual energy value of conventional fuels was considerably higher than its accepted price, which reflected a monopolistic agreement between suppliers and consumers. Hence, renewable energy sources were subject to unfair competition. Federally sponsored research and development had to restore the market's energy pricing imbalance.[12]

In addition, the major corporations producing conventional fuels tended to stress profitability in fossil fuel exploitation. Responsible to their respective shareholders to boost sales and improve profits, private corporations were reluctant to develop expensive energy alternatives, including renewable energy sources. Consequently, an energy-short government such as the United States would find it desirable to finance this type of energy research.[13]

Witnesses also contended that American corporations hesitated to invest in long-term energy projects in which initial capital investment was high relative to the short-term return. Given the trend of ever higher conventional fuel prices, it was believable that renewable energy costs would eventually be sufficiently competitive for private industry to market. If the federal government financed the time-consuming and costly research and demonstration projects, interest in renewable energy sources would be heightened and costs would be cut at about the time that fossil fuel use would lose its price attractiveness. Then, the argument went, private industry could exploit the alternative sources. In summary, even though few energy experts questioned the long-term profitability of renewable power, most congressmen believed that industry would not put capital resources into this area before the government illustrated the probability, if not the certainty, of short-term economic gain.[14]

Finally, some economists, including Heiss, recalled that energy would hardly be the first technology funded by the federal government. The government had contributed heavily to civilian research in the private communications and aviation industries and, in the public sphere, to agriculture and the space program.[15]

## Solar Energy Development

In developing such popular renewable energy sources as solar energy, Senator Hubert H. Humphrey was convinced as far back as 1962 that the federal government had to take the lead in research, primarily by establishing a government laboratory exclusively for solar energy research. Representative Mike McCormack, who had worked as a chemist at Hanford, presented a convincing argument in late July 1974 for federal involvement in solar energy research.

> Because solar energy research requires close integration among scientists--each with a specific competence--and a considerable amount of specially designed equipment, the country needs a national laboratory devoted to solar energy research and development problems. In this laboratory, we would be able to draw together a critical mass of the required scientists and their specialized equipment. Provisions for a solar energy research institute, therefore, are included in the bill.

McCormack envisioned a solar federal laboratory that "would be analogous" to the Atomic Energy Commission's nuclear research facilities. He suggested that the new laboratory be located at a new site or an existing federal building.[16]

Other House sponsors of federal solar research, such as Olin E. Teague of Texas and Frank E. Moss of Utah, emphasized the importance of government involvement. In order to drive home his argument, Teague included a 1973 Washington Post editorial in his extended remarks. The Post drew upon a 1972 report by the National Science Foundation and NASA to contend that solar energy would never be widely adopted in the United States if the government was unwilling to take the lead.

This, the paper asserted, could be done by having the government declare publicly its research commitment and by spending billions of dollars to finance research and development. The *Post* categorically rejected continued federal efforts that were confined to paltry laboratory research grants and small-scale experimentation. Moss seconded Teague's implied argument, asserting that the "leisurely approach" of giving limited research monies to colleges had to yield to a reliance on federal agencies, like NASA especially, which had "a proven capability in solar research."[17]

In final form, the Solar Energy Research, Development, and Demonstration Act of 1974 embodied congressional desire to assist solar research in three basic ways:

1. To define and fund a "well-thought-out" comprehensive federal program.

2. To provide a coordinated project that would draw upon hitherto dispersed solar research sponsored by the National Science Foundation, NASA, Housing and Urban Development, Atomic Energy Commission, and the Federal Power Commission.

3. To set up a federal solar energy task force to remove barriers to private companies seeking to conduct solar research and development.[18]

## Geothermal Energy

When considering geothermal energy after the oil embargo, Congress reiterated its belief in federally sponsored research. Congressional witnesses reported that geothermal research and development had been afflicted with a host of major difficulties, not the least of which were inadequate federal attention and funding, program fragmentation, and lack of private involvement. Impressed with the need for immediate action, Congress ignored an administration request to delay funding a geothermal energy program until ERDA was operating. Instead, it established the Geothermal Energy Coordinating and Management Project, which was given the responsibility of directing all research and development activities in the government, including the National Science Foundation, the Atomic Energy Commission, the Interior Department, and NASA.[19]

While most congressmen were persuaded that the marketplace could not quickly match the "overwhelming need" for geothermal energy, they believed that the private sector could still play a significant role. Senator Alan Bible, second-ranking member of the Committee on Interior and Insular Affairs, told committee members that, if only government and industry scientists and engineers were given federal resources, energy could be extracted from earth-heat, just as had been done with the atom. He argued that the major impediment to geothermal exploitation was in the Nixon administration's relative reluctance to fund federal research. Chairman Frank Church of the Subcommittee on Water and Power Resources agreed, urging the adoption of joint government-industry programs. To encourage private involvement in research and development, Congress made a provision in its 1974 geothermal law for a loan guarantee program in which the government would guarantee up to 75 percent of the aggregate cost, or a maximum of $25 million, for each eligible project.[20]

## Nonnuclear Energy Research and Development

By the end of 1974, Congress finally acted to implement its research objectives for nonnuclear energy sources in a systematic fashion. The Federal Nonnuclear Energy Research and Development Act was a measured response to congressional perceptions that American research and development activities in alternate power sources continued to experience "fragmented management, overall inadequate funding, and uncoordinated distribution of the meager funds...available." Speaking before the Senate Committee on Interior and Insular Affairs in the summer of 1973, Jerome B. Wiesner, president of the Massachusetts Institute of Technology and former science adviser to President Kennedy, claimed that federal energy efforts were doomed as long as the government persisted in "doling out little contracts and trying to mastermind the integration of groups of people that ought to be done on the spot."[21]

What, then, was the solution to stillborn federal energy research and development? According to Wiesner, Joseph C. Swidler, chairman of the New York State Public Service Commission, and such sympathetic Senators as Mark Hatfield of Oregon, the government had to pattern its alternate fuel program after the highly successful ones in the Atomic Energy

Commission, NASA, and the Department of Defense. Wiesner argued that these programs had succeeded "because they have been carried out by substantial collections of people in national centers or laboratories that had the resources and the energy to do the job." He called on Congress to set up a powerful federal energy body, one that could mandate a unified policy and could respond at will to changing research or market conditions. Repeatedly, he suggested that Congress adopt a tightly managed federal energy research and development policy, consistent with overall energy policy.[22]

Ultimately, Congress concluded that alternate energy development depended on industrial research participation. But on the crucial matter of how to divide responsibility between government and industry, energy experts offered little guidance. At one point in committee hearings, Louisiana Senator J. Bennett Johnston, Jr., persistently asked the President's energy consultant: "What should our direction be? Should the Government get into research through AEC, or through some separate corporation, or should it be private industry with the help of Government capital or tax policy or grants or price accords?" Like the President's adviser, Chauncey Starr, president of the Electric Power Research Institute, conceded that he did not have the answer either, saying, "It's the nature of the role that is not clear." MIT President Wiesner admitted that the issue was "very complex" and that the situation might well change within a few months. In essence, these experts argued for "a mix," the exact nature of which would depend on, among other things, the type of fuel technology, the stage of development, and the state of the market.[23]

The Federal Nonnuclear Energy Research and Development Act reflected congressional ambiguity over the ways in which knowledge of energy systems was to be found and exploited. Here, Congress followed Arizona Representative Morris Udall's advice not "to get bogged down...over how to structure public-private involvement." The law gave the management project "broad authority" to pursue all of the necessary actions of a lead agency, including dispensing grants and contracts, and, in some cases, requiring private investment in research. In making such decisions about federal involvement in nonnuclear energy research, the law stipulated that the project administrator had to consider such factors as the urgency of the program and the hesitancy of private investors to become participants.[24]

## Conclusion

The nation had suffered a painful ordeal during the oil embargo of 1973-1974. Besides the inconvenience of temporary fuel shortages, Americans were as stunned by the realization that the country had an energy problem with no ready solution. President Nixon and the Congress struggled to handle the vexing situation. Together, they reached a tentative consensus that the country's shortage of energy was serious and demanded immediate attention. Such action, however, was likely to be costly, risky, and effective only in the long term. Given these impediments, the President believed that private industry was reluctant to undertake needed research and development, especially of renewable energy sources. Therefore, the federal government was obliged to conduct the requisite energy research in consultation with industry. But the government's role would be limited to the point at which industry would assume commercialization costs.

These conclusions helped shape the government's response to the energy problem. President Nixon advocated structural changes by pressing in turn for a federal energy office, then a department, and finally a research and development agency. Although Congress stopped short of approving Nixon's request for a separate federal energy department, it eventually established the Energy Research and Development Administration. In addition, Congress relied on governmental research programs to speed the country toward energy independence. It particularly looked to renewable energy as a solution, enacting four research, development, and demonstration acts in 1974 alone.

Both the President and the Congress thus envisioned an unprecedented shift in the way the nation conducted energy research and development. Heretofore, the federal government, except in nuclear technology, had merely supplemented the activities of private industry by providing technical services and information. Now, in time of a national crisis, the federal government had taken the lead in developing a comprehensive plan for energy research and development.

## NOTES

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23. *Ibid.*, pp. 191-94, 408, 420-21.

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# CHAPTER 6

# POLICIES AND PROGRAMS OF THE ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION 1975-1977

The severe energy shortage resulting from the 1973 oil embargo might have led Congress to reverse the government's historic practice of leaving industry the major share of energy research and development. But an influential 1974 energy study prepared by a special engineering task force that included Robert C. Seamans, Jr., president of the National Academy of Engineering, rejected this approach. The report recommended that the government eschew a "crash" program characterized by "heavy government direction and intervention":

> [I]nstead government's role should be to help overcome obstacles to private initiative and to encourage long-term developments that exceed the capacity of the private sector to assume prudent risks.[1]

Seamans had an opportunity to implement these ideas when President Ford selected him to head the Energy Research and Development Administration. Under legislation designed to streamline government energy research activities, Seamans consciously sought "to supplement but never displace the efforts of private industry."

## A Partnership with Industry

What made the agency different from most earlier federal energy research efforts was Seamans' insistence on a close working relationship, or "partnership," between government and industry through all phases of research. The new Administration planned to withdraw from energy technology development when it reached the commercial take-off point. In other words, as Seamans explained, the government had an obligation to assist private industry in areas that precluded reasonable investment, but its duty ended when commercial application was possible. Seamans argued that the private sector retained its role of converting and transporting energy found in mines, wells, and oceans, and from the sun to the consumer.[2]

Seamans recognized that different energy demands and technologies required a flexible bureaucratic response to research and development. He believed that the optimum program should include as much private sector involvement as possible. The Nonnuclear Research and Development Act of 1974 had granted the new agency broad powers to do exactly that through cooperative agreements, loans, and price guarantees. Seamans cited the federal coal research program, as it existed under the revamped guidelines of the Office of Coal Research, as the prototypical example of government-industry cooperation. Under it, industry participants contributed 25 percent of all of the agency's coal program costs, 33 percent of new pilot plants, and 50 percent of demonstration plants. Seamans recalled that the 50-50 relationship in demonstration programs was patterned after the atomic power demonstration agreements of the 1950s and 1960s.[3]

The new Energy Research and Development Administration foresaw three benefits to private sector participation in government energy research programs. The obvious first benefit came from reduced federal expenditures because private companies often had to assume a fixed portion of program costs. Second, private interaction with federal energy research and development projects created a "peer-review system" that helped short-circuit economically and technologically unsound schemes. Third, and related to the first two reasons, the private sphere contributed to greater project efficiency by managing many research and development operations. Perhaps the most important fact was that industry would gain technical knowledge for effective marketing of energy technology.[4]

Underlying the agency's initial plan was the conviction that all energy possibilities had to be taken seriously--nuclear power, coal, and renewable sources. The agency saw no scientific evidence that any particular energy technology was clearly superior to all others. Hence, it sought to encourage each energy possibility until it proved unattractive for commercial development. Seamans expected that the new agency would have to give priority to conservation research because fuel savings would come about most easily, preserve energy--however fleetingly, and improve the country's balance of payments. In developing near-term energy supplies, Seamans ranked coal first because its only substantial handicaps were health hazards and unaesthetic byproducts found in environmental pollution. He waived aside criticisms of nuclear energy, saying that the breeder reactor research was essential as a bridge to the time--probably in the next century--when renewable sources could supplement, if not supplant, all other energy forms.[5]

## The Role of Conservation

Agency releases labeled as "myth" the notion that energy conservation meant "curtailment, doing without." Seamans and his colleagues feared that the American consumer would resist sudden, substantial disruptions in lifestyle. Accordingly, the agency pursued research and development programs that incorporated energy savings in devices that consumers used on a daily basis, especially automobiles, appliances, and buildings. The intended result would be a continuing high living standard for most Americans.[6]

While its energy conservation research efforts were modest in comparison with its development programs, the Energy Research and Development Administration largely fulfilled the government-industry relationship laid out in its first-year plan. Its objectives were twofold: First, to "complement" private sector initiatives in process and those being planned; and second, to encourage the adoption of energy-saving technology and more efficient use in buildings and community systems. To achieve these goals, the agency focused on gathering and disseminating information on conservation.[7]

Three examples of the agency's conservation program illustrate the belief that the government should offer industry limited assistance. In 1975, the agency evaluated plans to improve the aerodynamic design of transportation vehicles. At the same time, the Administration began construction of an experimental home that would reduce, by half, the energy needed for heating and cooling. The agency also funded urban plans for comprehensive energy management and conservation in Clarksburg, West Virginia, and Hobbs, New Mexico. In these and other cases, the agency sought to play a secondary role to that of the private sphere and local government.[8]

## Coal Research

As Seamans conceded, conservation alone could not eliminate the need for energy supply development, most notably in coal, the nation's most abundant fuel. Coal burning had inherent pollution problems, which the nation was not prepared to overlook. The Administration saw the federal government's role in promoting wider coal usage as filling the void between private involvement and the public interest. The agency planned to bridge this void with two-thirds funding of pilot plant projects and one-half funding of demonstration plants. These cost-sharing schemes were aimed at eliciting "early industry involvement," which Seamans extolled.[9]

The Administration defined its role in basic coal research as identifying "those aspects of coal utilization that have high potential payoffs to society, but are not receiving adequate attention or funding." Congress had complicated this task by dividing coal research programs between the newly created agency and the Bureau of Mines, which remained responsible for mine productivity. The Administration focused on developing "environmentally acceptable" technology to convert coal to liquid and gaseous forms, to improve coal combustion techniques, and to study magnetohydrodynamics. For this work, the agency relied heavily on contracts with private coal and oil companies and on its national laboratories. All told, the Administration spent about 80 percent of its fiscal year 1977 fossil energy budget on coal.[10]

Coal gasification and liquefaction presented more technical and institutional difficulties than direct coal utilization. These problems notwithstanding, the Administration counted on coal conversion to assume much of the burden of heating and power generation presently borne by oil and gas. In the short term, the agency thought its "most significant impact" would come in this area, as it hoped to double industry coal capacity by 1985 and double it again by 2000. As with direct utilization, the federal government sought to accelerate private sector developments in coal conversion through such cost-sharing arrangements as those pioneered by the Atomic Energy Commission and the Office of Coal Research.[11]

## Synthetic Fuels

Because industry was already involved in oil shale development, the government-industry relationship differed from other synthetic fuel programs. The Administration tried to support private industry's research and development efforts in several ways. For example, the agency allowed industry to test synthetic fuel processes on shale-rich federal lands. It also made available the resources of its energy technology centers, especially those at Laramie, Wyoming. Again, the government solicited cost-sharing energy research projects with private industry, but this time industry was expected to contribute on a proportional basis. There was even consideration of a $2 billion loan guaranty program for synthetic fuels to protect industry from unsound initial investment in oil shale demonstration plants.[12]

## Petroleum and Gas Research

In research on petroleum and natural gas, the Energy Research and Development Administration followed the lead of the Bureau of Mines in the early postwar era. In both federal agencies, petroleum research centered on programrs complementing the activities of major oil corporations. Under the Federal Nonnuclear Energy Research and Development Act of 1974, the Administration had responsibility for research on secondary and tertiary recovery processes. For this purpose, the agency let contracts to study micellar polymers, improved waterflood technology, and carbon dioxide injection. The agency also shared costs with industry for field tests of new drilling equipment. Important as these activities were, petroleum research and development accounted for only $45.8 million in 1977, or slightly more than one-tenth of the entire fossil energy budget.[13]

Nuclear Research

The strategy of having government supplement energy research that industry considered excessively costly or risky applied to the liquid metal fast breeder reactor (LMFBR). Although the government would have to commit most of the funding in the first two decades, private industry was expected to pick up most of the cost as early as 1990. In the interim, the Energy Research and Development Administration called for the government to construct, operate, and maintain expensive breeder facilities, such as the Fast Flux Test Facility and physics experimental facilities, as well as LMFBR test centers at the Argonne and Oak Ridge National Laboratories. The agency's breeder expenses for basic research and development alone surpassed $300 million annually. The Administration anticipated increased industry participation as technology advances were made at pilot plants and at the Clinch River Breeder Reactor.[14]

The federal government continued to conduct important research to determine nuclear reactor safety, but divided the responsibility between the Energy Research and Development Administration and the Nuclear Regulatory Commission. When it created the Nuclear Regulatory Commission in 1974, Congress directed the new agency to perform "confirmatory assessment" research specifically related to regulatory decisions. Since then, just under half of the annual budget has gone for these research activities. In August 1975, the Nuclear Regulatory Commission and the Energy Research and Development Administration signed a memorandum of understanding for the Commission to conduct research at the Loss-of-Fluid Test (LOFT) facility, a 50 megawatt (thermal) experimental pressurized-water reactor, at the Idaho National Engineering Laboratory. Crucial to this research were investigations into the ability of the light-water power reactor to cool the nuclear core in the event of a loss of the normal coolant. Subsequently, until the accident at Three Mile Island in 1979 altered priorities, most reactor research was designed to contribute to the understanding of the margins of safety necessary for establishing licensing requirements.[15]

The imbalance in energy research funding between government and industry was even more pronounced in magnetic fusion, an alluring but highly elusive energy source. In 1976, the long lead time and commercial risks compelled the government to absorb more than 95 percent of research and development costs; industry contributed just $5 million. The Administration supported research in its national laboratories, including Oak Ridge, Los Alamos, Lawrence Livermore, and Argonne, and at Princeton and Pacific Northwest Laboratories.

In addition, the government underwrote important industrial programs at General Atomic Company, United Technologies, and Westinghouse. The private sphere, principally the Electric Power Research Institute, cooperated with federal fusion programs in the design and construction phases. Despite the government's predominance in the fusion research program, the Administration did not redefine its goal of encouraging greater private investment at the earliest moment.[16]

Renewable Resources

Agency officials expected that renewable sources would likely supply only a small fraction of the nation's needs before the next century. Thus, they foresaw considerable federal involvement until the private sector could install solar and geothermal energy systems on a wide scale. Government assistance seemed particularly necessary because renewable energy systems involved high capital costs that dampened consumer demand and investor interest. The agency's 1976 plan contended that government's role would diminish after 2000 as private industry saw lower renewable energy costs and a greater possibility of profits.[17]

Solar Energy

One of the Administration's more important renewable energy programs was solar heating and cooling, which typified the agency's energy research philosophy. The purpose was "to stimulate a public market" for solar heat applications for homes and buildings and agricultural and industrial processes. As the lead government agency in solar research, the Administration invited the cooperation of such other federal agencies as the National Science Foundation for heating and cooling, the Department of Housing and Urban Development for residential dwellings, the National Aeronautics and Space Administration for extraterrestrial research, the Department of Defense for military installations, the National Bureau of Standards for solar standards, the General Services Administration for federal buildings, and the Federal Energy Administration for programmatic costs and benefits analysis. The Energy Research and Development Administration also called for federally supported high-risk research--the kind that private industry, by itself, would not pursue completely--in national laboratories, universities, and industrial groups. By 1985, the agency believed, the first stage would end, resulting in ever greater private participation.[18]

Since Administration officials were convinced that an inadequate information base "hampered" the adoption of solar technology, they welcomed the congressional mandate to create the Solar Energy Research Institute (SERI). Intended to support the national solar energy program, SERI's tasks included the following functions:

* Identification of new techniques
* Basic and applied research
* Development of suitable materials and systems methodology
* Engineering and economic reports

* Technological assistance
* Creation of measurement standards[19]

In its short, three-year solar program, the Administration moved tentatively at first, and then decisively. As federal budget outlays zoomed from $14.9 million in 1975 to $116 million in 1977, the agency targeted buildings in twenty-two states and the Virgin Islands to demonstrate heating and cooling techniques. More importantly, in early 1976, the Administration started to build a five-megawatt thermal solar test facility at its Sandia Laboratories in Albuquerque, New Mexico, which became the world's largest installation of its kind.[20]

The congressional Office of Technology Assessment charged that the agency's solar energy program was underfunded and understaffed and that too much emphasis was being placed on solar electric research at the expense of solar heating and cooling. The Office of Technology Assessment also criticized the research program for not better relating the basic science functions to commercial aspects.[21]

## Geothermal Energy

The second research program in alternate energy sources authorized by Congress in 1974 was geothermal power. The Administration's plan set forth a full range of governmental activities to expedite private involvement. In one of its first actions, the agency formed and chaired the Interagency Geothermal Advisory Council, which created geothermal policy and coordinated programs. The Administration then tried to stimulate private participation, first by financing part of the initial cost of research, development, and demonstration projects that private industry, for whatever reasons, did not support. The Administration concluded that industry was reluctant to invest in geothermal energy for the same reasons that it shied away from other nonpetroleum sources--excessive capital requirements and financial risks and too diffuse benefits. Second, the Administration tried to assist geothermal commercialization by creating a federal loan guaranty program for small entrepreneurs, and generally attempting to ease leasing regulations of appropriate public lands.[22]

Before its termination in late 1977, the Energy Research and Development Administration became involved in several geothermal projects, most often in cooperation with other government agencies or private industry. In February 1975, the Administration, the state government of Idaho, and the Raft River Corporation jointly sponsored a deep-drilling experiment for geothermal hot water. Fifteen months later, the Administration explored the energy advantages of deep dry-rock systems when it set up a project with the San Diego Gas and Electric Company to build a ten-megawatt test loop facility at Niland, California. In addition to funding the operation, the agency provided technical support and research through the Lawrence Livermore National Laboratory. The Administration maintained that this joint government-industry project was ideally suited to stimulating alternate energy production.[23]

## Conclusion

Although the Energy Research and Development Administration existed for less than three years, Seamans and his staff were able in that short time to create the institutional base for a new agency encompassing research and development programs for all energy technologies included in federal legislation enacted after the oil embargo in 1973. In so doing, they added new dimensions to the role of the federal government in energy research and development. No longer was the federal government to be simply the reluctant manager and guardian of the nation's energy resources, responding only when called upon by industry to fund development programs beyond the scope of financial capabilities of private enterprise. No longer was the federal role to be limited to a few high-risk, long-term, high-payoff projects such as the breeder reactor and magnetic fusion.

Under the ominous threat to the national welfare and security posed by the oil crisis of the 1970s, Congress saw the need for a much more positive, all-encompassing role for the federal government, and the new agency under Seamans fulfilled that expectation. An effective response to the energy crisis seemed to demand strong leadership and unprecedented federal funding on a broad front that included prompt development of short-term technologies as well as continuing stable support for long-term, high-risk projects. At the same time, the federal role was not to be absolute or exclusive. The federal government was to lead the way in determining how available resources were to be allocated to the development of various technologies, but these decisions were to be made in consultation with private industry and in a way that would offer industry a full and effective partnership in the process. This cooperative approach proved highly effective, at least in terms of increasing federal support quickly. Moving forward on all energy technologies simultaneously, the agency succeeded in rapidly expanding federal expenditures--for example, more than eight times in solar energy and almost three times in fossil energy--within three years. Whether these sharp increases were a true measure of progress in technological development was still to be determined when the Department of Energy assumed the federal role in 1977.

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# CHAPTER 7

## CONSOLIDATION AND ARTICULATION OF FEDERAL ENERGY PROGRAMS, 1977-1980

Early in the 1976 presidential campaign, Jimmy Carter made reorganization of the federal government one of the primary goals of his administration. High on the new President's agenda was "the creation of a new and comprehensive Department of Energy" to replace the "more than 50 different Federal agencies" which shared responsibility for energy policy and its execution. The purpose of the new department was "to channel research and development funds in a way that would be consistent with the long-range energy needs of our country."[1]

### The Department of Energy Organization Act

The provisions of the several bills affecting energy research and development were revised and expanded several times during five months of congressional hearings and debates in 1977, but they continued to reflect the initial views of the Carter administration.[2] The Department of Energy Organization Act declared that federal "responsibility for energy policy, regulation, and research, development, and demonstration" was so fragmented that it did not allow for "effective coordination of energy supply and conservation programs." The new Department was intended to have the power and authority to formulate and implement a national energy program. Thus, the Carter administration envisaged a federal role going beyond research and development to include the formulation of a national energy policy, of which research and development would be an integral part. Specifically, the Department was "to carry out the planning, coordination, support, and management of a balanced and comprehensive energy research and development program, including:

> "(A) assessing the requirements for energy research and development;
>
> "(B) developing priorities necessary to meet those requirements;
>
> "(C) undertaking programs for the optimal development of the various forms of energy production and conservation; and
>
> "(D) disseminating information resulting from such programs, including disseminating information on the commercial feasibility and use of energy from fossil, nuclear, solar, geothermal, and other energy technologies."[3]

The Act also required the Department "to place major emphasis on the development and commercial use of solar, geothermal, recycling, and other technologies utilizing renewable resources."

The Act provided for eight Assistant Secretaries, one of whom was to have responsibility for research and development in specified fields, the order of which suggested the priorities of the new administration:

(1) solar energy resources

(2) geothermal energy resources

(3) recycling energy resources

(4) the fuel cycle for fossil energy resources

(5) the fuel cycle for nuclear energy resources.[4]

The final section of the Act affecting research and development established an Office of Energy Research, to be headed by a Presidential appointee. The director was to monitor the Department's physical research and development programs and to advise the Secretary on matters related to physical research and the management of the multipurpose laboratories, except for the weapons laboratories. This section grew out of concerns within the universities that the basic research projects in the universities funded by the Energy Research and Development Administration (ERDA) would be lost in the new Department. Provision for the Office of Energy Research assured that research would continue to be a vital part of the federal role.[5]

## Review of the Liquid Metal Fast Breeder

Long before the new Department was created, President Carter took steps to reduce the federal government's commitment to nuclear energy. In February 1977, James R. Schlesinger, the President's energy advisor, announced that the administration was proposing to cut almost $200 million from the fast breeder reactor program in the 1978 budget. Schlesinger expressed strong doubts about the merits of the breeder program in general, the Clinch River Breeder Reactor specifically, and the use of plutonium in commercial power reactors. Because the new administration assigned its highest priorities to conservation and near-term supply technologies, the liquid metal fast breeder reactor no longer seemed viable. Schlesinger asked ERDA to make an intensive review of the breeder project. Although most of the members of the ERDA review panel believed that the federal government should preserve the breeder option, the administration attempted to cancel the Clinch River project, a move that resulted in a running battle with Congress through the end of the Carter presidency. The breeder decision did provide an early illustration of the President's determination to exercise decisive executive control over the priorities assigned to developing energy technologies.[6]

## Synthetic Fuels

One of the President's priorities was to create a domestic synthetic fuels industry. Drawing on the Federal Nonnuclear Research, Development, and Demonstration Act of 1974, the administration obtained $2.2 billion "to provide support to industry for planning, designing, and constructing" synthetic fuels projects. Of this amount, only $200 million went to feasibility studies and to projects beyond the feasibility stage; the remainder was allocated to a loan guarantee reserve and to purchase commitments and price supports.[7]

The Energy Security Act of 1980 provided additional authority for a "synfuels" program. The Act created the U.S. Synthetic Fuels Corporation, which was authorized to employ a variety of financing devices to reach a 1987 goal of 500,000 barrels of oil per day. These devices included price guarantees, federal purchase agreements, direct loans, and loan guarantees--all designed "to achieve maximum leverage within the private sector." The Energy Department was expected to offer technological, economic, and environmental assistance when the Corporation became operational in 1981.[8]

## Renewable Energy Sources

Although President Carter had declared his intention to support the development of renewable energy sources, he did not believe that they could help to meet energy demands in the short term. He favored intensive development of energy conservation measures and greater use of coal for immediate needs, while renewable energy sources were developed for the more distant future.[9]

The President's proposal, however, conflicted with the views of some congressional leaders who envisioned a much more important role for renewable sources, developed with federal research monies. The legislative preference for renewable energy had gained momentum in the process of creating the Department of Energy and giving it central authority over all significant energy issues. As a result, Congress, led by Henry M. Jackson, Mike McCormack, and Olin E. Teague, enacted additional legislation. These laws included the Solar Photovoltaic Energy Research, Development, and Demonstration Act of 1978; the Energy Security Act of 1980; the Ocean Thermal Energy Conversion Research, Development, and Demonstration Act of 1980; and the Wind Energy Systems Act of 1980.

## Solar Photovoltaic Energy Research

Solar photovoltaic cells to convert the sun's energy directly into electricity were developed by the Bell Telephone Laboratories in the 1950s, but they were too expensive for commercial marketing. The space program later proved the feasibility of photovoltaic technology, but cell costs remained economically uncompetitive. In 1977, industry announced breakthroughs in solar cell technology and requested long-term federal assistance in research and development.[10]

In response, Congress passed the Solar Photovoltaic Energy Research, Development, and Demonstration Act of 1978, which authorized $125 million for the first year of a 10-year project estimated to cost $1.5 billion. The Energy Secretary received discretionary authority to select solar cell developmental programs for funding either with contracts or grants to public and private institutions. To assist the Secretary in selecting projects, the law established a Solar Photovoltaic Energy Advisory Committee, comprised of members from academic, industrial, and research institutions. The Act directed the Secretary to initiate an "aggressive" solar cell research program, to double the production of solar cell systems, to reduce costs, and to increase and private purchases of solar systems.[11]

According to Representative Mike McCormack, the solar photovoltaic bill presented Congress with a golden "opportunity to take positive action in the development of renewable alternative energy sources." Noting that the Carter administration was supporting a more modest proposal, McCormack recalled that a parade of qualified committee witnesses testified that the federal government should lead photovoltaic development in the coming decade. His committee agreed unanimously that the government could achieve this goal by taking two specific actions:

1. Follow a publicly declared, predictable, and specific program aimed at lowering per-unit solar cell costs.

2. Fund photovoltaic energy research and development heavily at first; then, gradually taper off federal involvement in order to encourage participation by private industry.

Many congressmen saw an important link between these two objectives. If the government research program, however funded, reduced solar energy conversion costs, then industry could assume its traditional role of further technical refinement and marketing.[12]

## Biomass Energy

By 1979, Congress looked with growing interest at another alternate fuel--biomass energy (bioenergy)--which it defined as "the stored energy of plants." In hearings before the House Subcommittee on Energy Development and Applications, representatives and energy experts pointed to several factors that made such energy exploitation desirable. These included the ready availability of enormous forest resources, technical feasibility of biomass conversion systems, and environmental advantages.[13]

As Congress saw matters, bioenergy had not been as fully supported as other alternative power sources. Biomass was the "orphan child" of energy possibilities. This neglect had occurred because bioenergy had no powerful constituent interest group promoting it, as did the oil, nuclear, and coal industries. Despite the Carter administration's oft-stated goal of including bioenergy among the renewable sources that could supply one-fifth of the nation's needs by the end of the century, administration budgets devoted less than 8 percent of current energy research monies to it. According to one congressman, "biomass simply gets no attention" from the Department of Energy. Federal agencies, particularly the Department of Agriculture and the Department of Energy, had overlapping jurisdiction over bioenergy, and there was "virtually no substantive coordination or program planning" between them. Moreover, it was noted that the Department of Energy itself had at least eleven separate programs concerned with bioenergy development. For this reason, Congress had provided inadequate oversight of bioenergy programs, a serious weakness given what some representatives regarded as a lip-service commitment to them.[14]

The bioenergy bill became Title II of the Energy Security Act of 1980. According to the Act's provisions, biomass and alcohol-derived fuel enhanced national security by providing an environmentally acceptable and economically competitive energy alternative to some of the unreliable petroleum imports. The Act stipulated that the Energy

Secretary had to devise a plan, in consultation with the Department of Agriculture, to develop bioenergy fully, and that he was authorized to make biomass and alcohol research grants to colleges, universities, and government corporations to achieve the plan's objectives. The Act also set minimum percentages for allocating funds for bioenergy research in order to direct development along certain lines. For example, the Secretary was instructed to direct at least 25 percent of the rural, agricultural, and forestry biomass budget on research into alcohol production.[15]

Previous to the bioenergy act, most federal research monies for this purpose had been allocated to a staff office in the Department of Energy headquarters. This branch referred particular aspects of research to field offices and laboratories. The Solar Energy Research Institute, for example, took charge of alcohol fermentation and anaerobic digestion, as well as advanced research and development aspects. Other bioenergy research projects were divided between Oak Ridge, the San Francisco Operations Office, and scattered individuals at other laboratories.[16]

## Ocean Thermal Energy Conversion

Congress continued its basic approach to alternative energy development in 1980 under the Ocean Thermal Energy Conversion Research, Development, and Demonstration Act. The federal government's involvement in ocean thermal research began in 1972, when the National Science Foundation established its first solar energy program. When ERDA was set up three years later, ocean thermal research was transferred to it. By the end of the decade, much of the basic research had already been completed, but Vice Chairman Spark M. Matsunaga of the Subcommittee on Energy Research and Development, author of the ocean thermal research and development bill, dismissed the notion that no additional research and development was needed. On the contrary, he argued, the scientific and industrial communities strongly endorsed "an accelerated R. & D. program" on a long-term basis in order to make ocean thermal technology commercially available.[17]

Ocean thermal technology attracted congressional support because it appeared to be nonpolluting, recyclable, and inexhaustible. The Cousteau Society estimated that ocean thermal energy had the potential of providing enough energy to supplant "millions of nuclear plants." Another attraction of ocean thermal plants was that they could be located on islands, such as Hawaii and Puerto Rico, that were almost completely dependent on imported petroleum for their energy. Ocean thermal plants also promised valuable byproducts such as ammonia, which, with minor changes, could power automobiles, leaving only the nonpolluting end-products of water and nitrogen. The ocean thermal process could also supply potable water to nearby areas with insufficient reserves.[18]

In July 1980, Congress approved the ocean thermal bill, which closely paralleled other renewable energy acts in two respects. First, the Act placed greatest emphasis on the demonstration of power technology in order to entice commercial investment. Second, the Act gave considerable discretionary power to the Energy Secretary in research and development. The Secretary was to receive technical advice from a panel consisting of industrial, academic, and government laboratory scientists, and from financial and environmental representatives. But the final decisions would remain in his hands; he would determine the distribution of federal research monies. In large measure, such discretion reflected a widespread understanding that energy development was often uneven, requiring a "flexible" research effort.[19]

## Wind Energy

Wind energy attracted congressmen for the obvious reasons related to renewable power sources. Beyond its virtues of being pollution-free and inexhaustible, wind energy had special appeal. For one thing, most Americans understood and identified with wind energy. It was hardly exotic, given the old windmills that dotted the American rural landscape. Second, wind systems required very little energy for their operation. Third, wind power sites tended to be widely dispersed throughout the country, rather than being confined regionally, as were geothermal and ocean thermal sources. Fourth, the President's domestic policy review of solar energy had recently reported that "there are no technological breakthroughs necessary" for wind energy development. In addition to these favorable qualities, many congressmen simply believed that the complexity of the energy problem meant that "we have to try all possible avenues," including wind.[20]

In 1979, Congress supported wind energy research and development programs that were similar to those set forth in solar, biomass, and ocean thermal legislation. The heart of wind energy development seemed to be in demonstration projects and private investment. Representative James J. Blanchard, one of the bill's authors, told a House energy subcommittee that corporations, whose primary goal is "profit-making," would not undertake substantial new energy development programs like wind systems "without some form of government carrot to make it worthwhile." Federal support would be important when technical difficulties arose in pilot programs. Because such problems could not be pinpointed in advance, Congress permitted executive discretion in allocating research funds.[21]

Congress passed the Wind Energy Systems Act in 1980, a law admittedly patterned after the 1978 photovoltaic statute. The purpose was to make wind energy competitive by enunciating a clearly stated, ambitious goal for wind energy capacity; funding an "aggressive" eight-year program; establishing a cost-sharing scheme in which federal aid would subsidize the difference in cost between wind energy systems and conventional fuel prices; and eliminating federal involvement when the Department of Energy determined that wind energy could compete in the fuel marketplace. As in earlier alternate energy laws, the Secretary of Energy was empowered to pursue any wind energy proposal that he deemed appropriate.[22]

## Conclusion

During the Carter years, congressional commitment to alternate energy sources, such as solar photovoltaic cells, bioenergy, and ocean thermal and wind energy, remained stronger throughout than the President's. Both Carter and Congress saw an important role for renewable energy in meeting national needs, but they disagreed on the timing of that role. While the President viewed such sources as vital in the twenty-first century, Congress believed that these energy forms could make contributions in as little as five years. Both sides cited now familiar advantages of alternate energy systems--namely, that they were inexhaustible, reliable, nonpolluting, and cost-competitive.

Not surprisingly, these differing views influenced perspectives on alternate energy research and development. The President increased federal support for renewable sources, but not as steeply or systematically as Congress desired. The President put his faith in energy stop-gap measures like conservation and coal. In the aftermath of the oil embargo, most congressmen had become convinced that the nation needed to reduce sharply its dependence on a single fuel and especially to push development of all practicable alternatives. Since these alternatives required significant further research, development, and marketing, Congress reasoned that only the federal government could bridge the energy gap until industry believed its involvement would be profitable. Thus, the four alternate energy bills enacted in 1980 all gave the federal government a significant role in research and development.

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10. House Committee on Science and Technology, Report on the Establishment of a Solar Photovoltaic Energy Research, Development and Demonstration Program, 95 Cong., 2 sess., November 4, 1978, 92 STAT. 2513-22.

11. Ibid., p. 6; Solar Photovoltaic Energy Research, Development, and Demonstration Act of 1980, (P.L. 95-590), 95 Cong., 2 sess., November 4, 1978, 92 STAT. 2513-22.

12. Congressional Record, 95 Cong., 2 sess., June 28, 1978, pp. 19378-82, 19384.

13. House Committee on Science and Technology, *Hearing on the Biomass Research and Development Act*, November 15, 1979, (Washington, 1980), pp. 34, 36, 39-42, 48, 63.

14. *Ibid.*, pp. 34, 36-39, 43.

15. *Energy Security Act*, (P.L. 96-294), 96 Cong., 2 sess., June 30, 1980, 94 STAT. 683, 687, 705-06.

16. House Committee on Science and Technology, *Hearing on the Biomass Research and Development Act*, November 15, 1979, (Washington, 1980), pp. 66, 109-10.

17. Senate Committee on Energy and Natural Resources, *Hearing on the Ocean Thermal Energy Conversion Research, Development, and Demonstration Act*, October 15, 1979, (Washington, 1980), pp. 1-2; *Congressional Record*, 96 Cong., 2 sess., January 25, 1980, pp. S425-6; Senate Committee on Commerce, Science, and Transportation, *Report on the Ocean Thermal Energy Conversion Act of 1980*, 96 Cong., 2 sess., May 15, 1980, p. 3.

18. Senate Committee on Commerce, Science, and Transportation, *Report on the Ocean Thermal Energy Conversion Act of 1980*, pp. 2-3.

19. *Ocean Thermal Energy Conversion Research, Development, and Demonstration Act of 1980*, (P.L. 96-310), 96 Cong., 2 sess., July 17, 1980, 94 STAT. 942-3, 945.

20. House Committee on Science and Technology, *Hearings on the Wind Energy Systems Act of 1980*, September 18, 24, 1979, (Washington, 1980), pp. 7, 11, 33, 64, 214, 229.

21. *Ibid.*, pp. 8-9.

22. *Ibid.*, pp. 3, 14-15; *Congressional Record*, 96 Cong., 1 sess., December 3, 1979, p. H11445; *Wind Energy Systems Act of 1980*, (P.L. 96-345), 96 Cong., 2 sess., 94 STAT. 1141-2, 1146.

# CHAPTER 8

# POLICIES AND PROGRAMS OF THE DEPARTMENT OF ENERGY, 1977-1981

President Carter's approach to energy research and development went considerably beyond the traditionally limited government role. Prior to his administration, the private sector had assumed the major responsibility for development in all but the most advanced technologies. Even in the Energy Research and Development Administration, federal participation in energy research did not extend into areas that industry could support. Carter, in contrast, tended to think that industry was unable to respond effectively to national energy demand.[1]

## The Carter Energy Plan

While the Energy Research and Development Administration had repeatedly emphasized private industry's role in research and development, Carter placed his faith in government programs. In fact, the strategy of his first National Energy Plan centered on what the government, not industry, could do:

> [T]he nation should pursue a vigorous research and development program to provide renewable and other resources to meet U.S. energy needs in the next century. The Federal Government should support a variety of energy alternatives in their early stages, and continue support through the development and demonstration stage for technologies that are technically, economically, and environmentally most promising.[2]

The administration planned to finance most energy research, except for a few programs like conservation, in which broad cooperation was necessary from the beginning. In developing fuel technologies, the Department took most of the responsibility for making them available to industry for mass marketing. At that point, the administration proposed to provide industry with government assistance in the form of loan guarantees, tax breaks, and reduction in bureaucratic procedures. Government and industry in the Carter years often had distinct, rather than overlapping, roles in energy development.[3]

Consistent with this view of the government's responsibility, the Carter administration sharply increased federal funding for energy research and development. During its first three years of operation, the Department of Energy spent for research and development 63 percent more on fossil fuels, 311 percent more on solar energy, and 237 percent more on conservation than did the Energy Research and Development Administration in a similar period. Indeed, the Department funded nearly all areas of energy research much more heavily than did its predecessor.[4]

The first Secretary of Energy, James R. Schlesinger, former head of the Atomic Energy Commission, departed from traditional practices of organizing energy agencies. In an important first step, he tailored his research and development programs to support the President's energy plan. Secondly, he rejected the old approach of assigning departmental functions on the basis of fuel technologies. Instead, he used stages of development as his organizing principle.

These decisions conformed with Schlesinger's thinking that the Department's purpose was "to focus on the end objectives of the Nation and to avoid preoccupation with individual sources of energy, such as natural gas." In other words, each stage of energy technology development would be administered separately from every other stage and would be assigned to a single departmental office.[5]

Office of Energy Research

The Office of Energy Research was responsible for the first stage in the research and development process for all technologies. Its obligations included research in the basic energy sciences and nuclear physics, activities related to the Department's research and development programs in various fuel technologies, and management assessment of the Department's multiprogram nonweapon laboratories. The office's director executed these responsibilities through advisory and review groups, such as the Research and Development Coordination Council and the Energy Research Advisory Board. The office also strengthened its commitment to research in basic energy sciences, because these areas were seen as the foundation for development of "high risk, high-payoff" technologies in which scientific or technological feasibility remained unproven.[6]

## Energy Technology

The second stage of energy development was assigned to the Office of the Assistant Secretary for Energy Technology, the Department's "engineering arm." The technology office applied energy research to develop the technical basis for new energy sources, such as renewable energy, and to use conventional fossil fuels more efficiently. In all its programs, the office supported only potentially "marketable products." As in the Energy Research and Development Administration, the Energy Department's technology office placed technologies in three categories: (1) the near-term, which included enhanced oil and gas recovery, improved coal combustion methods, and more reliable nuclear reactors; (2) mid-term, which included synthetic fuels and renewable energy from some solar, geothermal, and biomass technologies; and (3) long-term, which included magnetic fusion, fission breeders, and photovoltaic technologies. The office made only passing reference to the need to inform industry and the public of technological advances. While it declared that the government "should not support research where the funds are more properly provided by private sources," this statement meant little, given industry's hesitancy to finance needed energy research.[7]

Although the Assistant Secretary for Energy Technology recognized the necessity for industry to be "integrally involved," he laid far less stress on cooperative government-industry ventures than did the Energy Research and Development Administration. The Energy Department did participate in some cost-sharing projects with industry. One, to improve the performance of internal combustion engines for automobiles, included several national laboratories, Princeton University, and General Motors Research Laboratories. The Department also engaged in cost-sharing plans to increase oil recovery and to improve fuel-cell efficiency. But these cooperative efforts were the exception rather than the rule. In cases where industrial energy research was inadequate, Secretary Schlesinger seemed to prefer contractual projects with industry and universities. For example, the Department awarded contracts to firms that would design and construct test facilities for coal liquefaction and gasification, as well as more efficient wind turbines.[8]

The development of solar technology offered some insight into the Energy Department's reliance on government programs. In March 1978, the Assistant Secretary for Energy Technology defined his responsibilities in solar energy as follows:

1. To select the most attractive "market-relevant systems" to displace exhaustible conventional fuels.

2. To pursue an "aggressive sequential development and demonstration" program.

3. To reduce costs for each system through a "market-pull approach" in which the government stimulated private manufacturing and distribution by purchasing solar equipment for specific early applications in the private sector.

4. To maintain "limited" research and development incentives, such as a beneficial tax package, until industry would market the systems on its own.

In the last point, the Assistant Secretary acknowledged that industry would market solar systems only when they became profitable. The use of market forces by the Department, rather than a government-industry partnership, was to be the impetus for development.[9]

## Resource Applications

The third step in the research and development process was assigned to the Assistant Secretary for Resource Applications or to the Assistant Secretary for Conservation and Solar Applications. In 1978, the Department's commercialization task force identified nine technologies that appeared closest to market readiness. The Assistant Secretary for Resource Applications then assigned managers for each marketable technology to design a market strategy that would overcome commercial barriers. Among other devices, these managers employed financial incentives, favorable leasing terms, and demonstration programs. To speed commercial adoption, the Department also continued the federal loan guarantee programs for medium-sized coal companies and geothermal firms, which had first been set up under the Energy Research and Development Administration.[10]

## Reorganization under Secretary Duncan

The Department's experiment in organizing research and development along functional lines ended soon after Charles W. Duncan, Jr., replaced Schlesinger as Secretary in 1979.

In October, Duncan reorganized the Department to return to the traditional organization by energy technologies. Under the new plan, the Office of Energy Technology was eliminated and new assistant secretaries appointed for fossil and nuclear energy. Somewhat inconsistently, Duncan retained the Assistant Secretary for Resource Applications. Minimizing the significance of these changes, the new Secretary asserted that "[t]his realignment does not disturb organizational relationships within the Department, but gives us a better approach, in my judgment, to the management of the Department's activities."[11]

Like Schlesinger, Duncan thought that the federal government should assist the nation in developing acceptable alternatives to oil. In his view, the government could use several techniques to fulfill its responsibility, including direct expenditures for research and development and the removal of existing barriers to the marketing of technology. The government could also use such financial incentives as tax credits, loan guarantees, and grants to encourage private firms to produce alternate fuels and to market new energy technologies. But Duncan publicly disagreed with Schlesinger on the proper relationship between government and industry in developing nonconventional fuels. Whereas Schlesinger, by implication, emphasized the government's role, Duncan stated his position unequivocally in his first annual report to Congress: "The prime responsibility for the development of alternate energy sources lies with the private sector."[12]

In his seventeen-month tenure as Secretary, however, Duncan did not appreciably deviate from the Schlesinger pattern. He continued to fund energy research, development, and demonstration projects in which industry was the contractor rather than a genuine, or full-fledged, partner of government. Moreover, the Department's emphasis remained focused largely on short-term results, whereas the Energy Research and Development Administration had supported all energy technologies. The following examples in synthetic fuels, nuclear power, and conservation illustrate this point.

## Coal Research

The Department's coal program was designed to develop methods that would encourage the substitution of coal resources for petroleum and natural gas. As a result, the coal budget far exceeded the amounts allocated for those technologies. While the Department supported new methods of coal extraction and new technologies for coal burning in an environmentally acceptable manner, its greatest effort went into establishing a synthetic fuel industry "at the earliest practicable time." Secretary Duncan believed this goal could be reached only if the "Department of Energy will continue to be responsible for technology research, development, and demonstration." In practice, the Department usually signed contracts with industry to run a federally owned facility. At the demonstration stage, however, the Department sometimes supported conversion technologies through cost-sharing projects.[13]

The Department's H-Coal pilot plant in Catlettsburg, Kentucky, produced its first synthetic oil from coal in late May 1980 after three years of construction. This pioneer process was developed under a Department of Energy contract with the private firm of Ashland Synthetic Fuels, aided by the State of Kentucky and an industrial consortium headed by Hydrocarbon Research, Inc. To complete the project, the Department projected its own contribution to be $583.4 million and the private sector's at $38 million, none of which was anticipated to come after fiscal year 1982. In this case, the Department had abandoned the Energy Research and Development Administration's practice of requiring a fixed-percentage contribution from industry.[14]

## Fusion Energy

Nuclear fusion continued to represent a far more difficult energy technology than did coal. As a result, the government had customarily assumed the lion's share of research and development costs. In New Jersey, the Energy Department let a contract to Princeton Plasma Physics Laboratory to operate the Tokamak Fusion Test Reactor, which was being designed and constructed by three private firms. The government paid the entire $478 million project cost, as it did in its other current fusion projects.[15]

## Conservation

In its January 1981 annual report, the Department again declared that it had a "generic" role in conservation energy research. More particularly, the Department asserted that it should "encourage and coordinate RD & D" by offering tax incentives for energy conservation investments and government grants to selected contractors. Though the Department continued to use joint funding of energy projects, it preferred contracts and grants. For instance, the government anticipated funding the entire estimate of $362.2 million for developing advanced automotive heat engine systems.[16]

## Conclusion

The election of President Carter in 1976 had resulted in a dramatic shift in the federal role in energy research and development. In place of the broad approach adopted during the Ford administration, the new President and his advisors stressed technologies that were likely to produce results in the short term. The Carter administration also had less confidence in government-industry partnerships. Thus, the Department made heavy commitments to conservation measures and the development of synthetic fuels, usually in the form of direct contracts rather than partnership arrangements. In effect, the Carter administration believed that the federal government had to accept the responsibility for energy research and development up to the point of commercialization. These assumptions resulted in a substantial increase in federal expenditures for energy research and development, particularly for short-term technologies, during the Carter years. At the same time, the administration saw energy research and development not as an end in itself but rather as only one factor to be considered as part of an integrated national energy policy. The election of President Reagan in 1980, however, portended a sharp reversal in the trend toward an increasing federal role, which had begun with the oil crisis of 1973.

NOTES

1. Crauford D. Goodwin, ed., Energy Policy in Perspective: Today's Problems, Yesterday's Solutions, (Washington, D.C.: The Brookings Institution, 1981), p. 533.

2. "Testimony by James R. Schlesinger before the Senate Committee on Energy and Natural Resources," DOE, May 3, 1977.

3. Executive Office of the President, The National Energy Plan, April 29, 1977, p. 32.

4. Ibid., pp. 79-81; National Energy Plan II, A Report to the Congress required by Title VIII of the Department of Energy Organization Act (Public Law 95-91), U.S. Department of Energy, (Washington, D.C., May 1979), pp. 5-13.

5. "Briefing by James R. Schlesinger," Office of the White House Press Office, September 13, 1977; U.S. Department of Energy, Annual Report to Congress, 1978, (Washington, D.C., 1979), p. 49.

6. U.S. Department of Energy, Annual Report, 1978, pp. 25, 27-48.

7. Ibid., pp. 49-52.

8. Ibid., pp. 53-56, 59.

9. DOE/ET-0041(78), "Solar Geothermal, Electric and Storage Systems Program Summary Document," March, 1978, pp. 19-38.

10. U.S. Department of Energy, Annual Report, 1978, pp. 69, 71, 75.

11. "Remarks by Charles W. Duncan, Jr. at James Forrestal Building Press Conference," DOE, September 13, 1979; U.S. Department of Energy, Secretary's Annual Report to Congress, (Washington, D.C., January 1980), pp. 1-16, 14-2.

12. U.S. Department of Energy, Secretary's Annual Report to Congress, 1980, pp. 1-10, 1-11.

13. "Oral Statement by Charles W. Duncan, Jr., to the House Subcommittee on Energy and Power of the Committee on Interstate and Foreign Commerce," DOE, October 11, 1979; U.S. Department of Energy, Secretary's Annual Report to Congress, Vol. I, "Posture Statement, Outlook and Program Review," (Washington, D.C., January 1981), pp. 3-7; U.S. Department of Energy, Secretary's Annual

Report to Congress, Vol. II, "Budget Highlights," (Washington, D.C., January 1981), pp. 8-9.

14. U.S. Department of Energy, Secretary's Annual Report to Congress, Vol. III, "Project Summaries," (Washington, D.C., January 1981), pp. 12-13.

15. U.S. Department of Energy, Secretary's Annual Report, 1981, Vol. I, pp. 5: 24-7, Vol. III, pp. 64-69.

16. Ibid., Vol. I, pp. 2: 1-3, 8, 9, Vol. III, pp. 2-3.

APPENDICES

Organization Charts

Financial Data

CHART 1

ORGANIZATION OF THE U.S. ATOMIC ENERGY COMMISSION

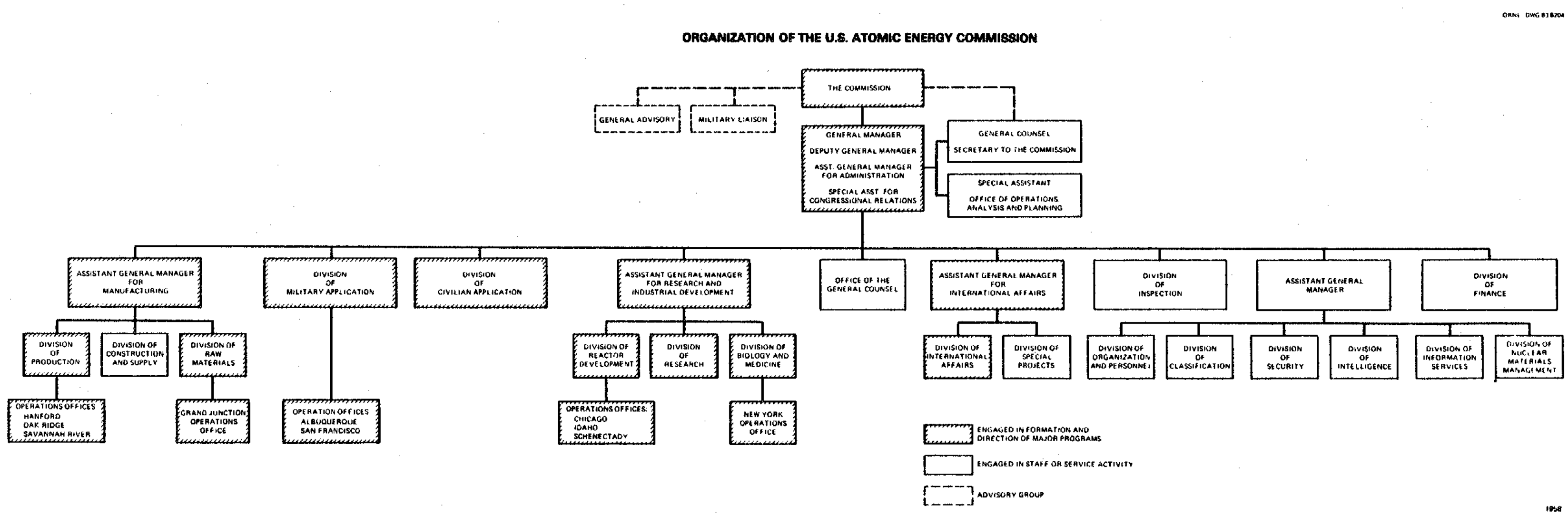
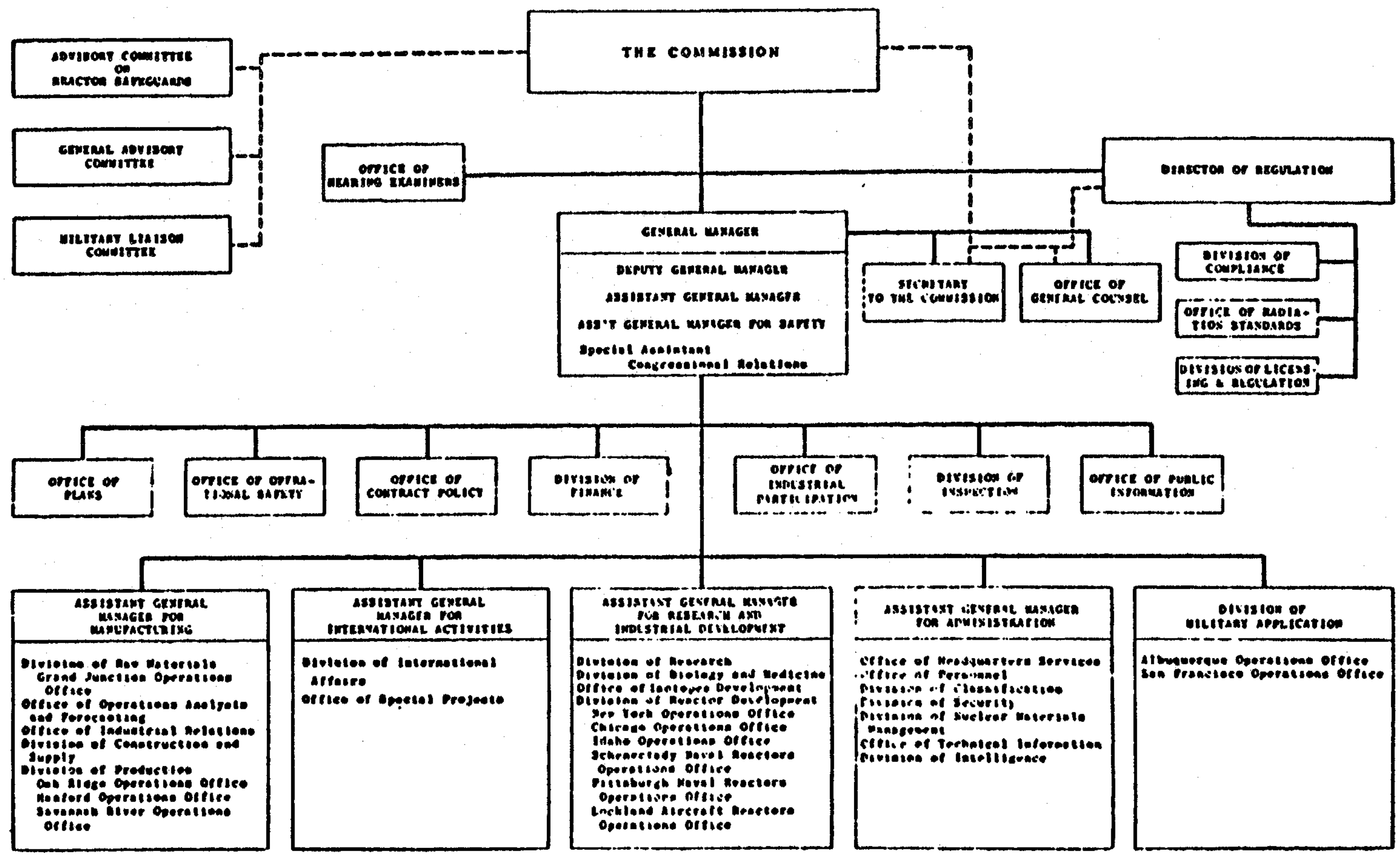


CHART 2

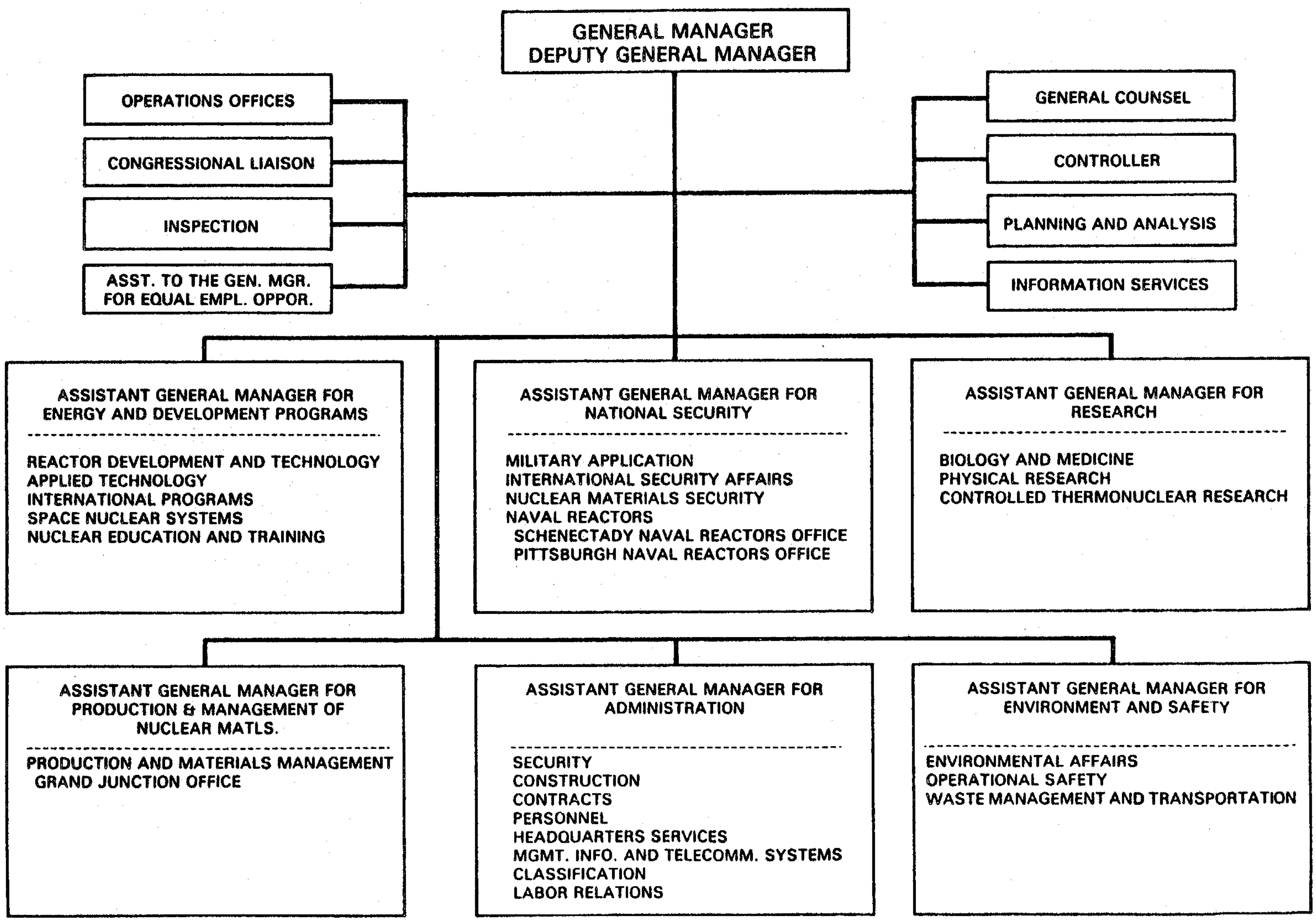
# ATOMIC ENERGY COMMISSION




1957

CHART 3

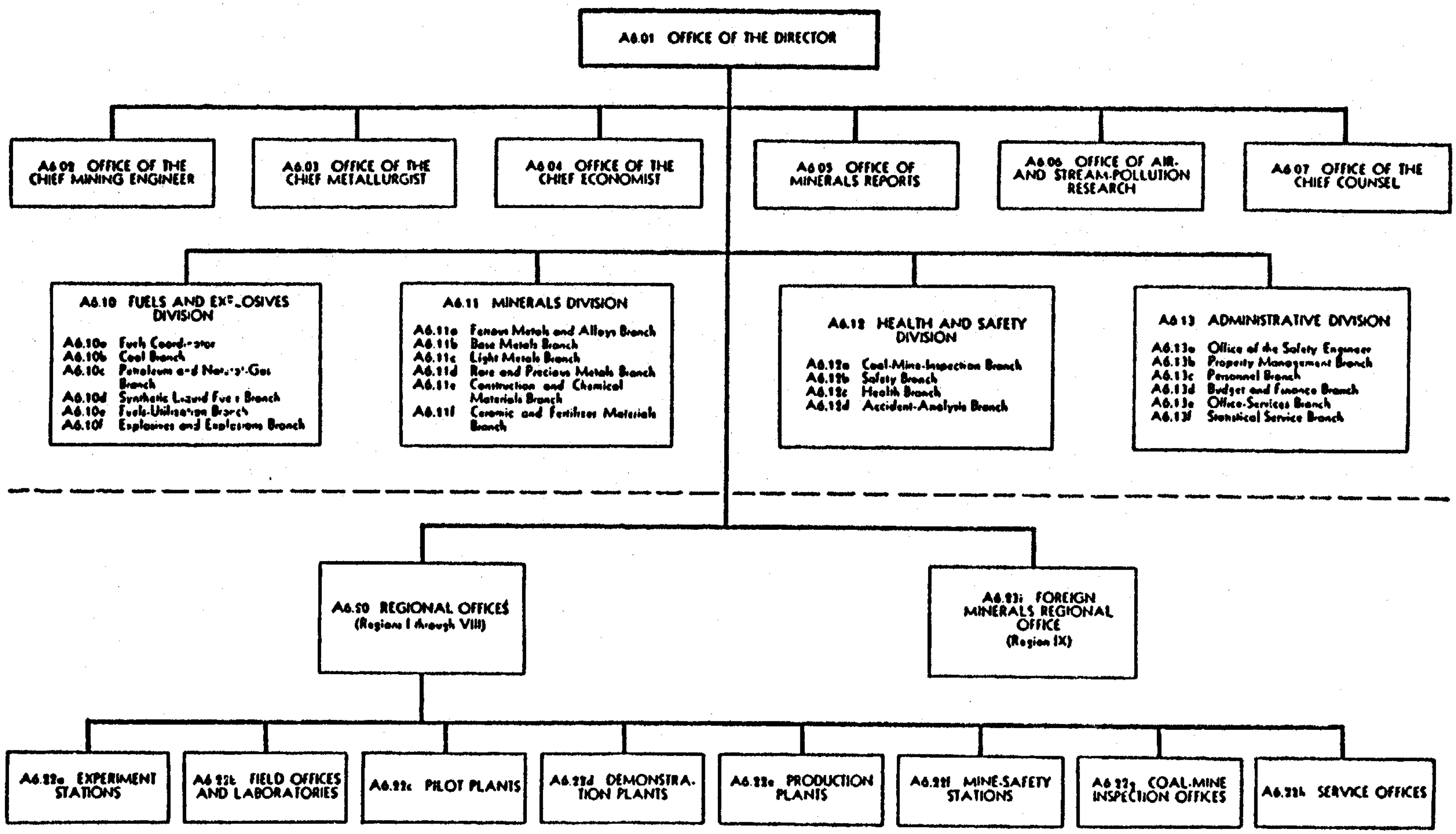
# UNITED STATES ATOMIC ENERGY COMMISSION




December 1971

CHART 4

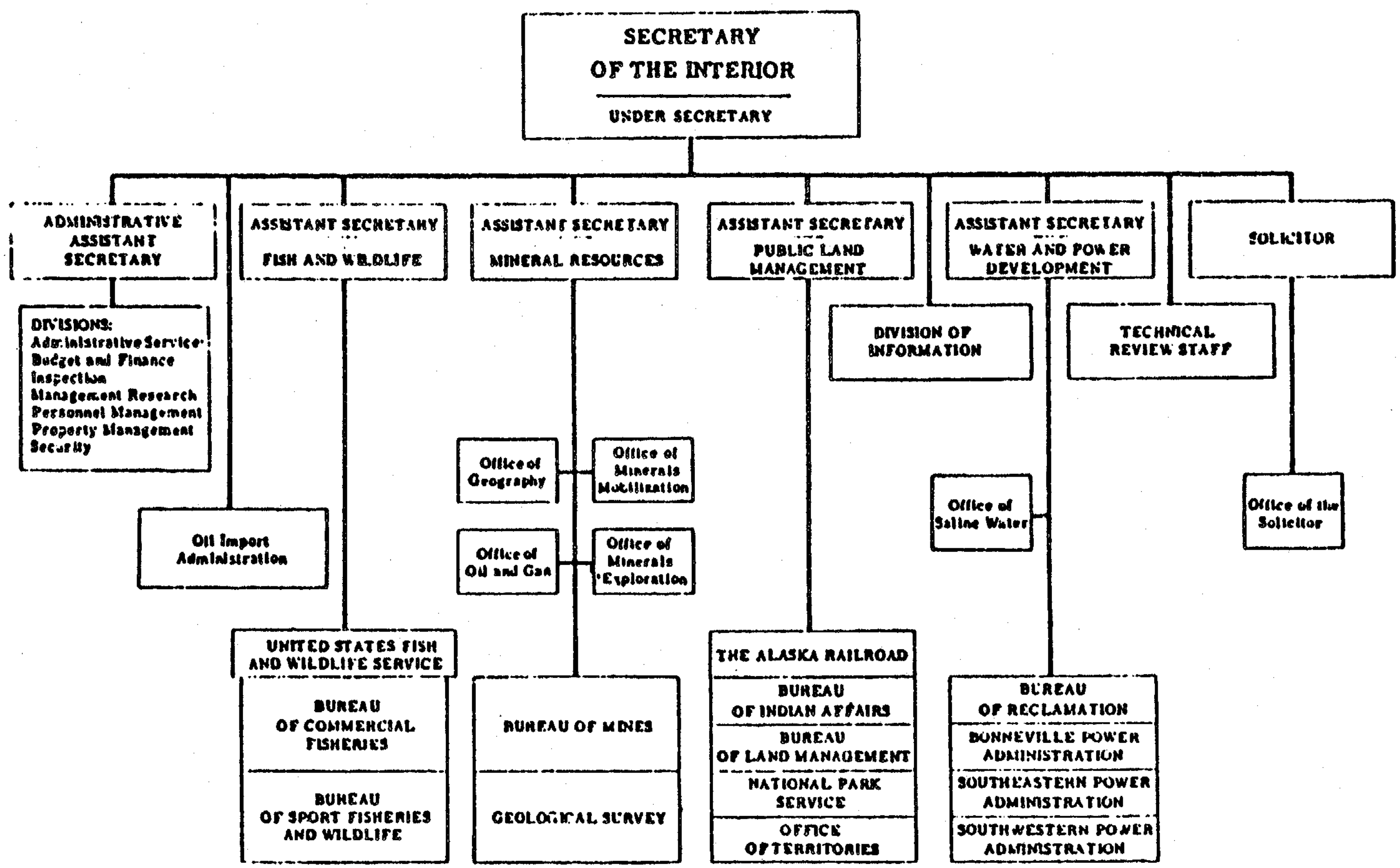
## ORGANIZATION OF THE BUREAU OF MINES




July 1951

CHART 5

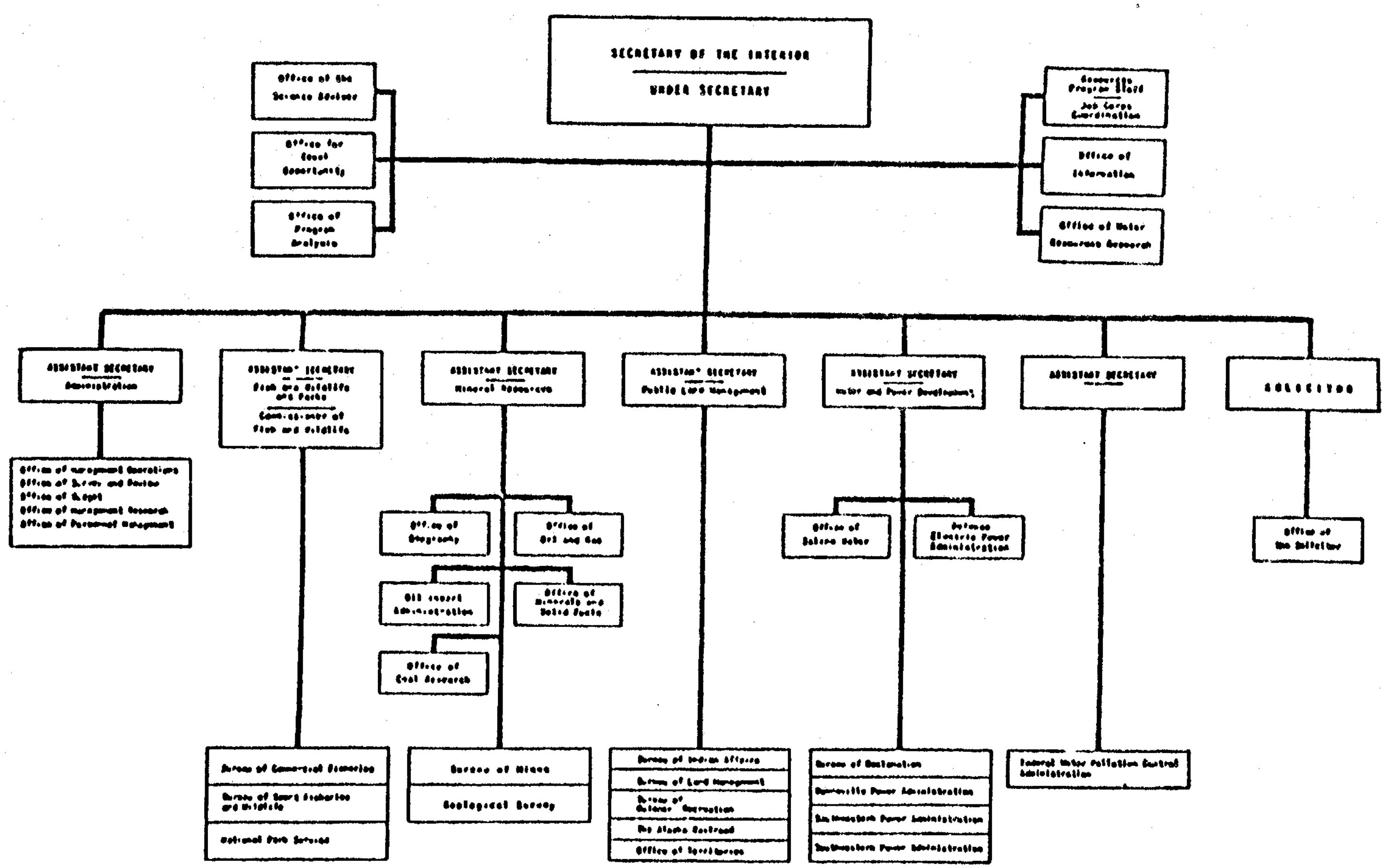
## DEPARTMENT OF THE INTERIOR




1960

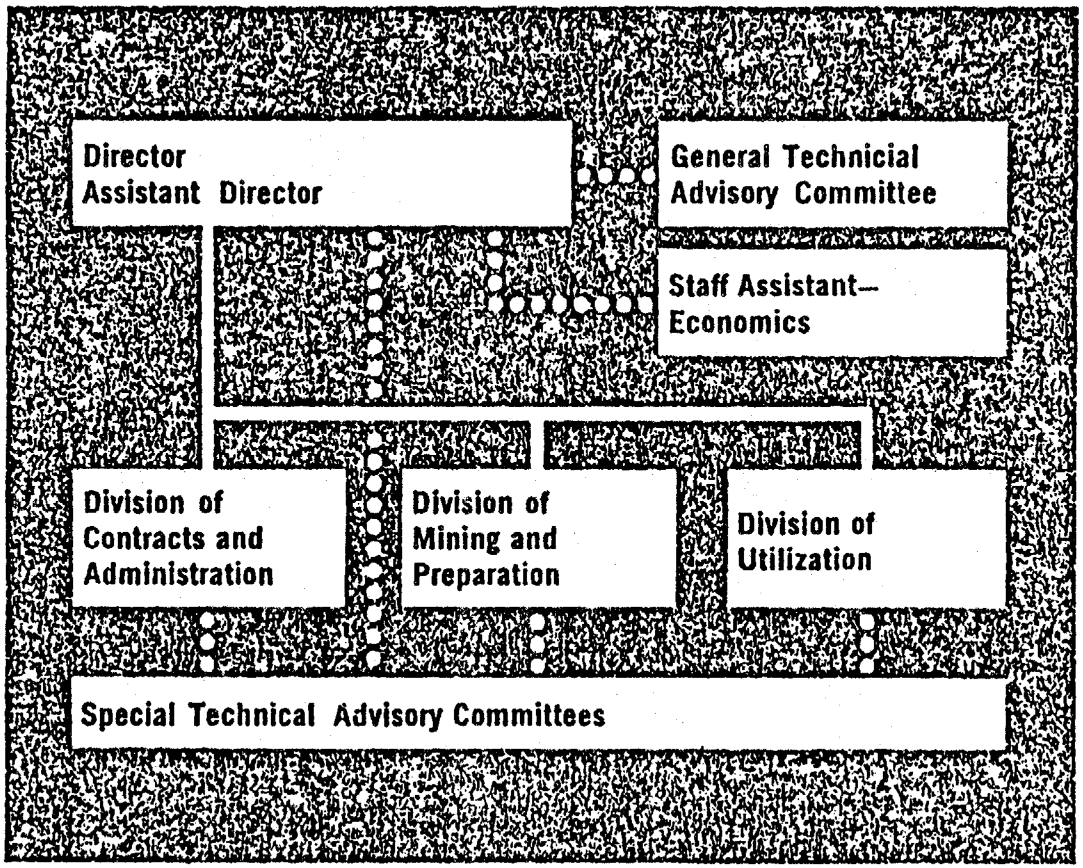
CHART 6

# DEPARTMENT OF THE INTERIOR




1966

CHART 7

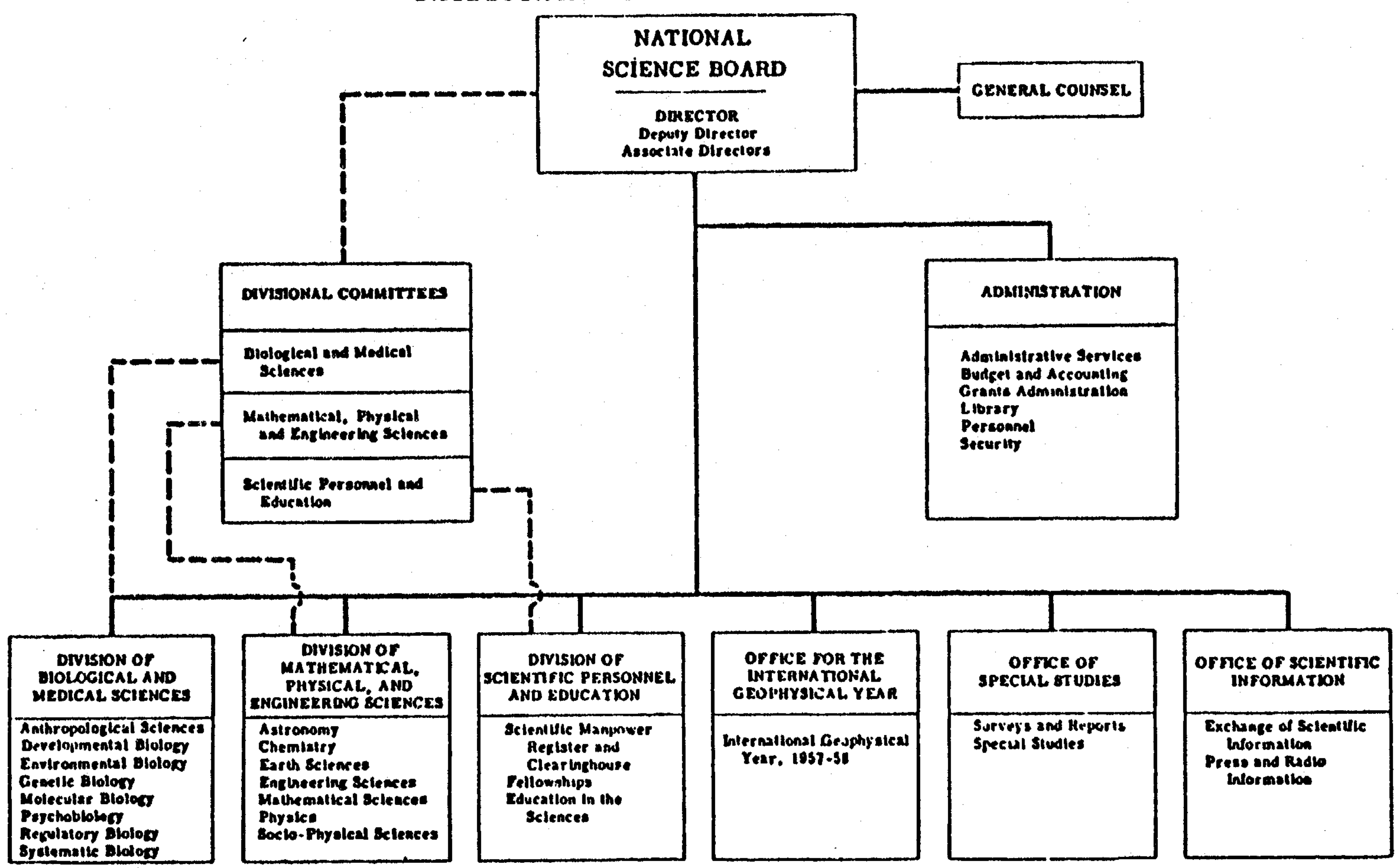



ORGANIZATION CHART
OFFICE OF
COAL RESEARCH

1969

CHART 8

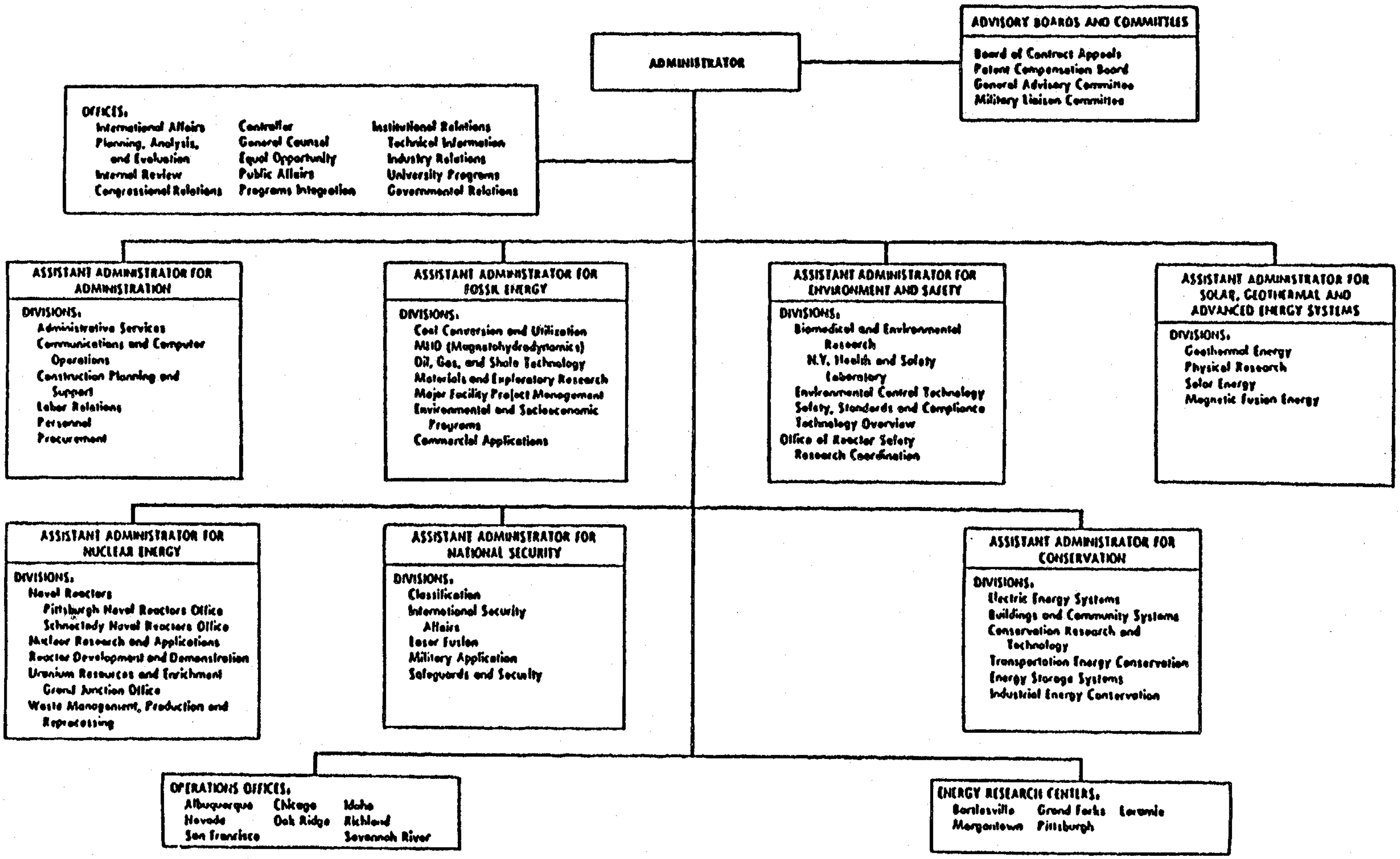
# NATIONAL SCIENCE FOUNDATION




1957

## ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

CHART 9



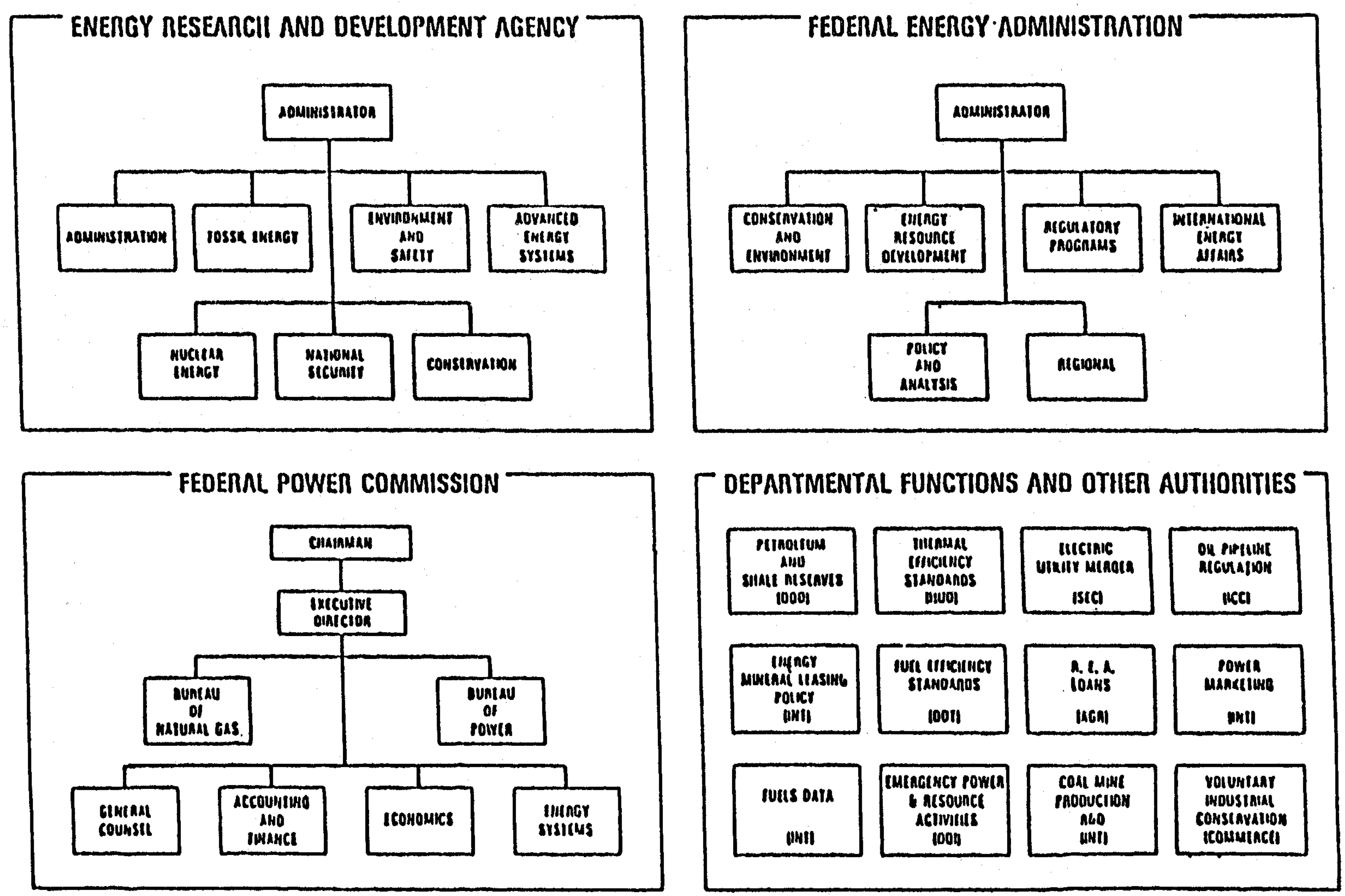

Offices and Divisions

June 1977

CHART 10

## Department of Energy

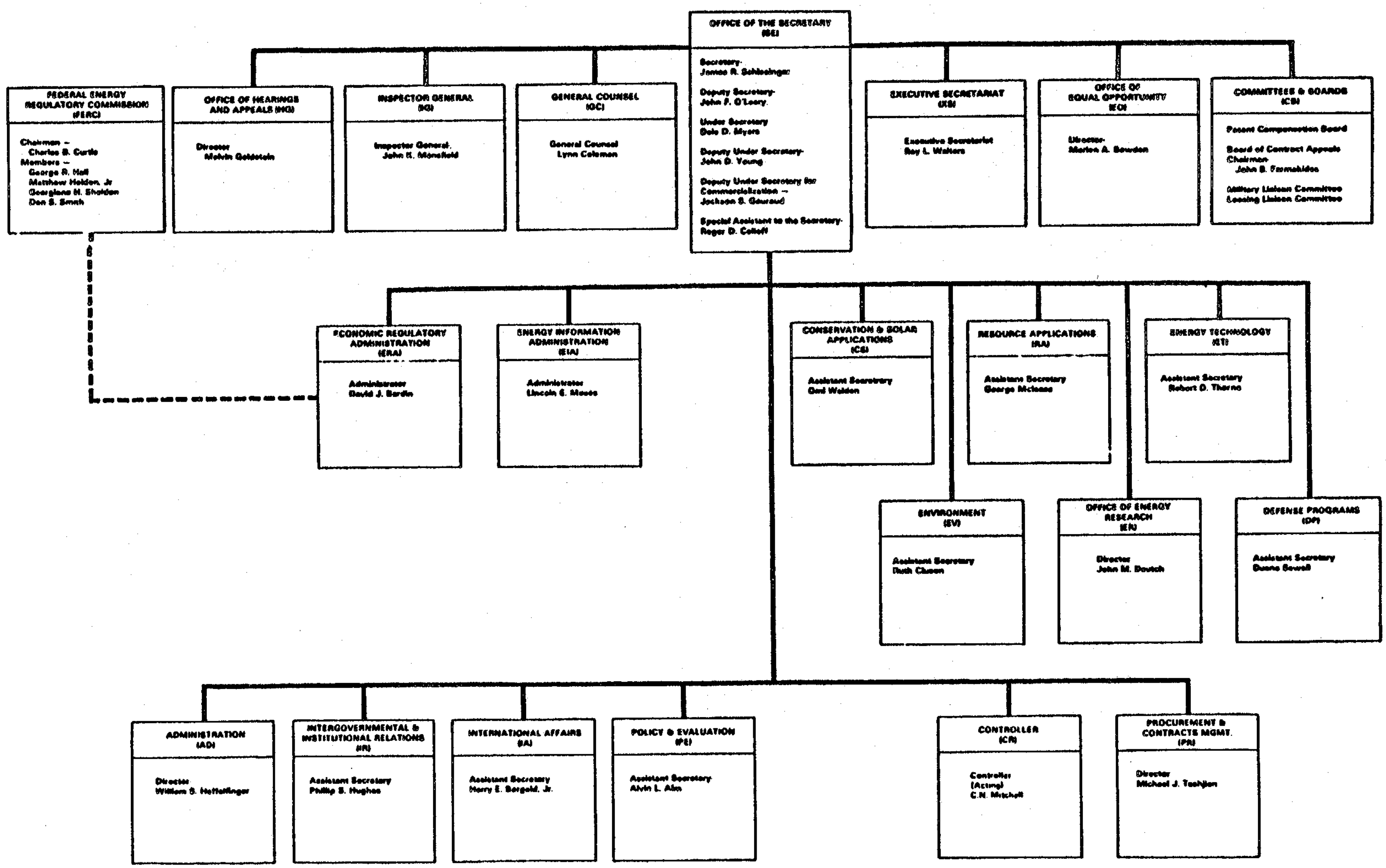
# Predecessor Organizations




1977

CHART 11

# Department of Energy Organization




September 10, 1978

CHART 12

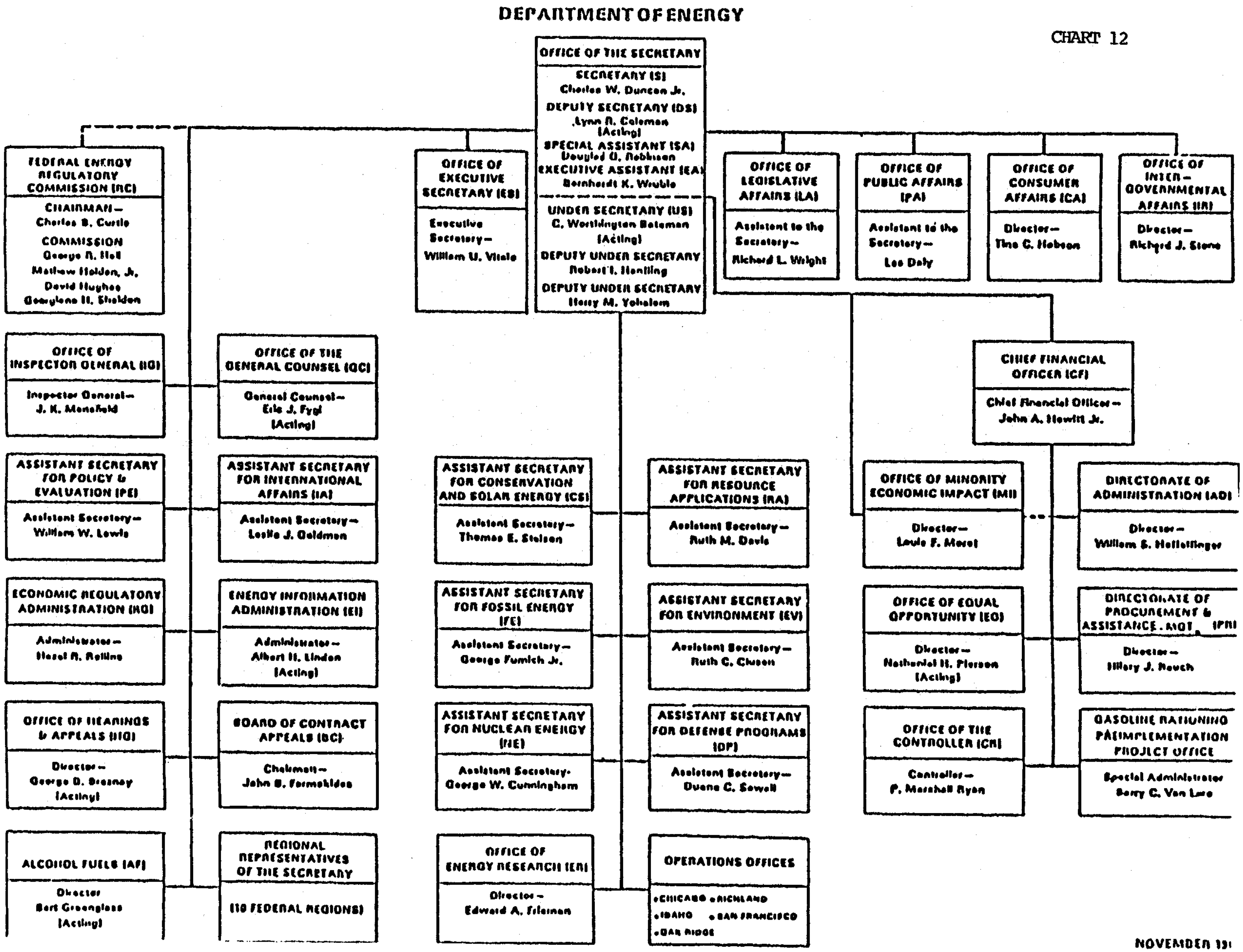

DEPARTMENT OF ENERGY
OFFICE OF THE SECRETARY
SECRETARY (S) Charles W. Duncan Jr.
DEPUTY SECRETARY (DS) Lynn R. Coleman (Acting)
SPECIAL ASSISTANT (SA) Douglas G. Robinson
EXECUTIVE ASSISTANT (EA) Bernhardt K. Wruble
UNDER SECRETARY (US) C. Worthington Bateman (Acting)
DEPUTY UNDER SECRETARY Robert I. Hanfling
DEPUTY UNDER SECRETARY Henry M. Yohalem
FEDERAL ENERGY REGULATORY COMMISSION (RC)
CHAIRMAN– Charles B. Curtis
COMMISSION George R. Hall, Matthew Holden, Jr., David Hughes, Georgiana H. Sheldon
OFFICE OF EXECUTIVE SECRETARY (ES)
Executive Secretary– William U. Vitale
OFFICE OF LEGISLATIVE AFFAIRS (LA)
Assistant to the Secretary– Richard L. Wright
OFFICE OF PUBLIC AFFAIRS (PA)
Assistant to the Secretary– Lee Daly
OFFICE OF CONSUMER AFFAIRS (CA)
Director– Tina C. Hobson
OFFICE OF INTER-GOVERNMENTAL AFFAIRS (IR)
Director– Richard J. Stone
OFFICE OF INSPECTOR GENERAL (IG)
Inspector General– J. K. Mansfield
OFFICE OF THE GENERAL COUNSEL (GC)
General Counsel– Eric J. Fygi (Acting)
CHIEF FINANCIAL OFFICER (CF)
Chief Financial Officer– John A. Hewitt Jr.
ASSISTANT SECRETARY FOR POLICY & EVALUATION (PE)
Assistant Secretary– William W. Lewis
ASSISTANT SECRETARY FOR INTERNATIONAL AFFAIRS (IA)
Assistant Secretary– Leslie J. Goldman
ASSISTANT SECRETARY FOR CONSERVATION AND SOLAR ENERGY (CS)
Assistant Secretary– Thomas E. Stelson
ASSISTANT SECRETARY FOR RESOURCE APPLICATIONS (RA)
Assistant Secretary– Ruth M. Davis
OFFICE OF MINORITY ECONOMIC IMPACT (MI)
Director– Louis F. Moret
DIRECTORATE OF ADMINISTRATION (AD)
Director– William S. Heffelfinger
ECONOMIC REGULATORY ADMINISTRATION (RG)
Administrator– Hazel R. Rollins
ENERGY INFORMATION ADMINISTRATION (EI)
Administrator– Albert H. Linden (Acting)
ASSISTANT SECRETARY FOR FOSSIL ENERGY (FE)
Assistant Secretary– George Fumich Jr.
ASSISTANT SECRETARY FOR ENVIRONMENT (EV)
Assistant Secretary– Ruth C. Clusen
OFFICE OF EQUAL OPPORTUNITY (EO)
Director– Nathaniel H. Pierson (Acting)
DIRECTORATE OF PROCUREMENT & ASSISTANCE MGT (PR)
Director– Hilary J. Rauch
OFFICE OF HEARINGS & APPEALS (HG)
Director– George B. Breznay (Acting)
BOARD OF CONTRACT APPEALS (BC)
Chairman– John B. Farmakides
ASSISTANT SECRETARY FOR NUCLEAR ENERGY (NE)
Assistant Secretary- George W. Cunningham
ASSISTANT SECRETARY FOR DEFENSE PROGRAMS (DP)
Assistant Secretary– Duane C. Sewell
OFFICE OF THE CONTROLLER (CR)
Controller– P. Marshall Ryan
GASOLINE RATIONING PREIMPLEMENTATION PROJECT OFFICE
Special Administrator Barry C. Van Lare
ALCOHOL FUELS (AF)
Director Bert Greenglass (Acting)
REGIONAL REPRESENTATIVES OF THE SECRETARY
(10 FEDERAL REGIONS)
OFFICE OF ENERGY RESEARCH (ER)
Director– Edward A. Frieman
OPERATIONS OFFICES
•CHICAGO •RICHLAND
•IDAHO •SAN FRANCISCO
•OAK RIDGE
NOVEMBER 19

Table 1

U.S. Bureau of Mines

RESEARCH EXPENDITURES

| | Anthracite | Bituminous coal | Sub-bituminous coal and lignite | Oil and gas | Synthetic liquid fuels |
|---|---|---|---|---|---|
| 1938 | $ 2,757 | $ 111,061 | $ 39,177 | $ 252,538 | $ 48,677 |
| 1939 | 2,809 | 129,997 | 32,624 | 259,715 | 46,939 |
| 1940 | 2,812 | 128,430 | 34,061 | 259,632 | 49,978 |
| 1941 | 2,778 | 130,695 | 32,908 | 259,649 | 63,736 |
| 1942 | 2,662 | 118,891 | 32,929 | 319,545 | 47,501 |
| 1943 | 2,757 | 125,535 | 29,357 | 444,535 | 101,877 |
| 1944 | 3,118 | 126,210 | 32,232 | 564,456 | 113,538 |
| 1945 | 84,361 | 132,405 | 34,769 | 666,542 | 5,111,975 |
| 1946 | 68,947 | 132,333 | 30,197 | 579,870 | 7,000,000 |
| 1947 | 102,026 | 467,044 | 229,270 | 826,750 | 5,250,000 |
| TOTAL | $275,027 | $1,602,601 | $527,524 | $4,433,232 | $17,834,221 |

Source: House Committee on Appropriations, Hearings on Interior Department Appropriation Bill for 1948 (Washington: Government Printing Office, 1947), p. 978.

Table 2

U.S. Bureau of Mines

FOSSIL ENERGY RESEARCH, OBLIGATIONS BY SOURCE
(in thousands)

| Program and Source | 1958 | 1959 | 1960 |
|---|---|---|---|
| Bituminous Coal | | | |
| Bureau of Mines appropriation | 5,914 | 6,216 | 6,216 |
| Department of the Air Force | 195 | 240 | 240 |
| Department of the Army | 102 | 111 | 111 |
| Department of Health, Education, and Welfare | 139 | 153 | 153 |
| Department of the Navy | 171 | 188 | 188 |
| Atomic Energy Commission | 180 | 108 | 108 |
| Bureau of Reclamation | 12 | 6 | 10 |
| Other agencies | 82 | 93 | 93 |
| Contributed Funds | 193 | 240 | 202 |
| TOTAL | 6,991 | 7,356 | 7,321 |
| Anthracite Coal | | | |
| Bureau of Mines appropriation | 875 | 938 | 938 |
| Petroleum, Natural Gas, and Oil Shale | | | |
| Bureau of Mines appropriation | 2,480 | 2,663 | 2,663 |
| Department of the Air Force | 69 | 103 | 103 |
| Department of the Army | 59 | 72 | 72 |
| Department of Health, Education, and Welfare | 95 | 98 | 90 |
| Bureau of Reclamation | 35 | 27 | 29 |
| Other agencies | 17 | 19 | 19 |
| Contributed funds | 197 | 309 | 304 |
| TOTAL | 2,954 | 3,290 | 3,279 |

Source: House Committee on Appropriations, Hearings on Department of the Interior and Related Agencies Appropriations for 1960 (Washington: Government Printing Office, 1959), p. 233.

Table 3

U.S. Atomic Energy Commission

CIVILIAN NUCLEAR POWER REACTORS
OPERATING COSTS
(in millions)

| Fiscal Year | Total | Res & Dev | Construction |
|---|---|---|---|
| 1948-50 | 3.1 | 2.2 | 0.9 |
| 1951 | 5.1 | 3.2 | 1.9 |
| 1952 | 6.3 | 5.9 | 0.4 |
| 1953 | 10.1 | 10.0 | 0.1 |
| 1954 | 18.9 | 18.9 | 0 |
| 1955 | 28.4 | 26.3 | 2.1 |
| 1956 | 55.2 | 45.8 | 9.4 |
| 1957 | 90.0 | 56.7 | 33.3 |
| 1958 | 132.6 | 78.7 | 53.9 |
| 1959 | 151.5 | 105.3 | 46.2 |
| 1960 | NA | 117.8 | NA |

Source: Atomic Energy Commission, Annual Financial Reports, 1956-1958

Table 4

U.S. Atomic Energy Commission

CIVILIAN NUCLEAR POWER, OPERATING COSTS
(in millions)

| Fiscal Year | Costs |
|---|---|
| 1961 | 102.3 |
| 1962 | 94.3 |
| 1963 | 88.1 |
| 1964 | 98.4 |
| 1965 | 98.1 |
| 1966 | 120.0 |
| 1967 | 141.0 |
| 1968 | 166.5 |
| 1969 | 152.4 |
| 1970 | 147.7 |
| 1971 | 155.7 |

Source: U.S. Atomic Energy Commission, _Annual Financial Reports_, 1962-1972

Table 5

U.S. Atomic Energy Commission

COOPERATIVE POWER PROJECTS, CUMULATIVE COSTS
(in millions)

| Thru Fiscal Year | AEC | Participants |
|---|---|---|
| 1960 | 57.0 | 120.9 |
| 1961 | 102.5 | 181.7 |
| 1962 | 122.2 | 237.4 |
| 1963 | 136.0 | 273.6 |
| 1964 | 156.9 | 298.0 |
| 1965 | 174.6 | 353.0 |
| 1966 | 133.6 | 435.7 |
| 1967 | 144.1 | 495.3 |
| 1968 | 117.8 | 442.0 |
| 1969 | 125.3 | 476.4 |
| 1970 | 128.8 | 527.3 |
| 1971 | 138.8 | 606.8 |
| 1972 | 142.0 | 653.1 |
| 1973 | 143.7 | 680.5 |
| 1974 | 145.1 | 707.9 |

Source: U.S. Atomic Energy Commission, Annual Financial Reports, 1961-1975.

Table 6

U.S. Atomic Energy Commission

PHYSICAL RESEARCH, OPERATING COSTS

(physics, chemistry, and metallurgy)

(in thousands)

| Fiscal Year | Costs |
|---|---|
| 1955 | $39,054 |
| 1956 | 45,846 |
| 1957 | 54,123 |
| 1958 | 63,483 |

Source: Atomic Energy Commission, <u>Annual Financial Reports</u>, 1955-1958

Table 7

U.S. Atomic Energy Commission

PHYSICAL RESEARCH, OPERATING COSTS
(in thousands)

| Program | 1958 | 1959 | 1960 | 1961 | 1962 | 1963 | 1964 |
|---|---|---|---|---|---|---|---|
| High energy physics | 19,146 | 27,517 | 32,263 | 47,521 | 58,676 | 73,123 | 89,757 |
| Fusion research | 19,012 | 27,685 | 32,148 | 30,136 | 24,998 | 26,204 | 22,914 |
| Chemistry research | 15,957 | 19,356 | 23,116 | 25,156 | 30,301 | 33,298 | 34,462 |
| Nuclear structure | 13,203 | 14,518 | 17,894 | 19,757 | 21,660 | 25,008 | 27,252 |
| Metallurgy, materials | 7,742 | 9,348 | 12,672 | 15,344 | 19,065 | 21,945 | 22,269 |
| Chemical processes | 5,751 | 5,712 | 5,811 | 5,333 | 5,776 | 5,684 | 5,593 |
| Isotope separation | 1,972 | 2,733 | 2,405 | 1,927 | 2,074 | 2,090 | |
| Computer research | 2,042 | 2,191 | 2,856 | 3,489 | 3,712 | 4,871 | 5,098 |
| Other research | 2,894 | 3,258 | 3,680 | 5,432 | 5,520 | 6,303 | 8,337 |
| Total | 87,719 | 112,318 | 132,845 | 154,105 | 171,782 | 198,526 | 215,682 |

Source: Atomic Energy Commission, Annual Financial Reports, 1959-1965

Table 8

U.S. Atomic Energy Commission

PHYSICAL RESEARCH, OPERATING COSTS
(in thousands)

| | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 |
|---|---|---|---|---|---|---|---|---|---|
| High energy physics | 98,816 | 112,519 | 126,034 | 137,225 | 149,620 | 151,945 | 148,437 | 146,651 | 160,115 |
| Medium energy physics | 6,281 | 10,169 | 12,564 | 12,847 | 13,039 | 14,750 | 15,420 | 15,619 | 19,099 |
| Low energy physics | 25,855 | 27,883 | 29,751 | 31,485 | 33,370 | 33,463 | 31,563 | 29,615 | 29,181 |
| Chemistry research | 52,052 | 56,446 | 60,888 | 62,939 | 64,960 | 64,260 | 61,595 | 50,945 | 56,711 |
| Metallurgy, materials | 24,644 | 27,875 | 30,842 | 30,763 | 31,889 | 31,943 | 30,865 | 36,056 | |
| Fusion research | 23,419 | 24,122 | 25,087 | 27,903 | 30,101 | 31,582 | 32,463 | 28,689 | 27,653 |
| Math & computers | 5,913 | 5,988 | 6,945 | 7,178 | 8,659 | 7,940 | 7,621 | 6,544 | 6,729 |
| Total | 236,980 | 265,002 | 291,911 | 310,140 | 331,638 | 335,883 | 327,964 | 322,119 | 299,478 |

Source: Atomic Energy Commission, Annual Financial Reports, 1965-1973.

Table 9

U.S. Energy Research and Development Administration

RESEARCH AND DEVELOPMENT, OPERATING COSTS BY TECHNOLOGY
(in millions)

| Technology | 1975 | 1976 | 1977 |
|---|---|---|---|
| Fossil Energy | 139.6 | 334.6 | 446.4 |
| Solar Energy | 15.5 | 98.6 | 178.5 |
| Geothermal Energy | 21.8 | 45.1 | 47.7 |
| Nuclear Energy | 852.6 | 1,447.0 | 1,390.5 |
| Physical Research | 182.1 | (656.4) | (600.7) |
| Magnetic Fusion | | 168.7 | 185.9 |
| High Energy Physics | | 245.4 | 210.4 |
| Basic Energy Sciences | | 242.3 | 204.4 |
| Conservation | 22.0 | 74.8 | 127.8 |
| | 1,233.6 | 2,656.5 | 2,791.6 |
| Total ERDA Net Operations Cost | 3,362.8 | 5,141.9 | 5,095.5 |

Note: The 1975 data reflect the operating results of prior periods based on the present program structure of ERDA. These data were compiled from the accounting records of ERDA and the agencies which transferred programs to ERDA.

The 1976 data cover a fifteen-month period, from July 1, 1975, through September 30, 1976.

Source: U.S. Department of Energy, Office of the Controller, "Energy Research and Development Administration: Financial Report, 1977," (June 1978), p. 41.

Table 10

U.S. Department of Energy

ENERGY RESEARCH AND DEVELOPMENT
(in millions)

| Technology | 1978 BA | 1978 BO | 1979 BA | 1979 BO | 1980 BA | 1980 BO |
|---|---|---|---|---|---|---|
| Fossil Energy | 757.0 | 657.5 | 760.6 | 726.1 | 835.8 | 790.6 |
| Solar Energy | 246.2 | 182.4 | 442.9 | 405.6 | 527.7 | 536.6 |
| Wind Energy | N/A | | (59.6) | (53.8) | (60.6) | (60.6) |
| Ocean Energy | N/A | | (41.2) | (36.7) | (43.0) | (44.0) |
| Alcohol Fuels | N/A | | N/A | | (22.0) | (22.3) |
| Biomass Energy | 20.8 | 15.2 | 42.4 | 24.1 | 33.0 | 38.3 |
| Geothermal Energy | 106.2 | 81.9 | 146.2 | 127.2 | 149.4 | 129.4 |
| Hydropower | 10.0 | 7.5 | 28.6 | 17.6 | 21.3 | 11.0 |
| Fission Breeder | 539.9 | 624.9 | 733.1 | 757.9 | 747.9 | 752.3 |
| Fission Converter | 228.4 | 198.2 | 70.9 | 61.1 | 60.3 | 69.8 |
| Light Water Reactor Facilities | 28.1 | 27.0 | 10.3 | 16.5 | 25.0 | 22.9 |
| Magnetic Fusion | 329.6 | 282.4 | 355.1 | 348.6 | 350.3 | 420.4 |
| Basic Energy Sciences | 182.1 | 180.6 | 204.7 | 200.3 | 225.1 | 235.8 |
| University Research Support | 1.3 | 1.3 | 6.2 | 5.9 | 11.8 | 11.2 |
| Conservation | 519.2 | 237.0 | 630.9 | 251.8 | 780.7 | 574.2 |
| | 2968.8 | 2495.9 | 3431.9 | 2942.7 | 3768.3 | 3592.5 |
| Total DOE Appropriations | 11103.1 | 7388.8 | 10867.7 | 8437.5 | 14288.1 | 8770.9 |

Source: Department of Energy, Office of Budget, "Appropriations Summary," 1980-1982 Submission Requests to OMB.

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